

601.220 Intermediate Programming

File I/O, assertion, math functions

Outline

- File input and output (fscanf, fprintf)
- Assertion
- Math library functions

Standard streams

We've seen I/O functions that work *only* with `stdin/stdout`

- `printf`, `scanf`

Others work with any file, including named files and the standard streams (`stdin/stdout/stderr`)

- `fprintf`, `fscanf`

C file I/O

```
fopen("output.txt", "w")
```

- Open file "output.txt" in writing mode ("w")

Possible modes:

- "r": reading
- "w": open file for writing
- "r+": open for reading & writing
- "w+": open file for reading & writing

"r" or "w" are common

Note: "w" and "w+" cause the named file to be overwritten if it already exists

C file I/O

`fopen` returns a `FILE*`, a pointer to a `FILE` struct

- We'll return to structs and pointers later

Equals `NULL` if `fopen` failed

- Always check, since reading or writing `NULL` causes a crash
- `NULL` is a special pointer value, usually equal to 0; common way to indicate failure for functions with pointer return type

C file I/O

- `feof(fileptr)` returns non-zero if we've read past the end of the file
- `ferror(fileptr)` returns non-zero if file is in an error state, e.g. if we've opened file for writing but then attempt a read
- `rewind(fileptr)` returns `fileptr` to beginning of file

C file I/O

```
// numbers.txt:  
10 20  
3 50  
100 -100  
400 -800
```

C file I/O

```
// file_io_loop_eg.c:
#include <stdio.h>
int main() {
    FILE* input = fopen("numbers.txt", "r");
    if (input == NULL) {
        printf("Error: could not open input file\n");
        return 1; // indicate error
    }

    int a = 0, b = 0;
    int numCollected = fscanf(input, "%d%d", &a, &b);
    while (numCollected == 2) {
        printf("%d\n", a+b);
        numCollected = fscanf(input, "%d%d", &a, &b); }
}

if (ferror(input)) {
    printf("Error: error indicator ");
    printf("was set for input file\n");
    return 2; // indicate error
} else if (numCollected != EOF) {
    printf("Error: could not parse line\n");
    return 3; // indicate error
}

fclose(input); // Close input file
return 0; // no error
```

C file I/O

```
$ gcc file_io_loop_eg.c -std=c99 -pedantic -Wall -Wextra
$ cat numbers.txt
10 20
3 50
100 -100
400 -800
$ ./a.out
30
53
0
-400
```

C file I/O

We saw that `printf` and `scanf` use the *standard streams*

You can refer to them by these names, defined in `stdio.h`

- `stdin`
- `stdout`
- `stderr`

You don't have to open or close them; C handles that

For example, `fprintf` can write to `stdout` like `printf`:

```
fprintf(stdout, "Hello, World\n");
```

C file I/O

In addition to being useful for printing output to a file opened using `fopen`, `fprintf` is also useful for printing error messages to `stderr`. For example:

```
FILE *in = fopen(filename, "r");
if (in == NULL) {
    fprintf(stderr, "Could not open '%s'\n", filename);
    return 1;
}
```

Assertions

```
assert(boolean expression);
```

- Assertion statements help catch bugs as close to the source as possible
 - Require `#include <assert.h>`
 - `boolean expression` is an expression that *should be true* if everything is OK
 - If it's false, program immediately exits with an error message indicating the assertion failed
- Starting with next programming assignment (HW3), you must create *test cases* using `assert`

Assertions

Assertions can help to make your assumptions clear

```
int sum = a*a + b*b;  
assert(sum >= 0);
```

```
if(isalpha(c)) {  
    assert(c >= 'A');  
    printf("%d\n", c - 'A');  
}
```

Assertions

assert is not for typical error checking

```
FILE* input = fopen("numbers.txt", "r");
if(input == NULL) {
    printf("Error: could not open input file\n");
    return 1; // indicate error
}
```

If checking for bad user input, or another strange but not impossible situation, use `if` and print a meaningful message. If you must exit, return non-zero to indicate failure.

If you're checking for something that implies that your program is incorrect, use `assert`

Assertions

```
// assert_eg.c:
#include <stdio.h>
#include <assert.h>

int main() {
    int n = 0;
    scanf("%d", &n);
    if(n == 0) {
        printf("n must not be 0\n");
        return 1;
    }

    int n_sq = n * n;
    assert(n_sq >= n); // if false, something's wrong

    float n_inv = 1.0 / n;
    printf("squared=%d, inverse=%0.2f\n", n_sq, n_inv);
    return 0;
}
```

Assertions

```
$ gcc assert_eg.c -std=c99 -pedantic -Wall -Wextra
$ echo 4 | ./a.out
squared=16, inverse=0.25

$ echo -2 | ./a.out
squared=4, inverse=-0.50

$ echo 0 | ./a.out
n must not be 0

$ echo 200000000 | ./a.out
Assertion failed: (n_sq >= n), function main,
    file assert_eg.c, line 12.
```

The last run fails due to overflow of int!

Math library

`#include <math.h>` **and** compile with `-lm` option

- `sqrt(x)`: square root
- `pow(x, y)`: x^y
- `exp(x)`: e^x
- `log(x)`: natural log
- `log10(x)`: log base 10
- `ceil(x)` / `floor(x)`: round up / down to nearest integer
- `sin(x)`: sine (other trigonometric functions available)

Math library

x and y arguments have type `double`

It's also OK to pass another numeric type, like `int`

- Argument type promotion: `int` \rightarrow `float` \rightarrow `double`

`-lm` includes the math library when *linking*; more on this next meeting.