Computer Science I

Loops

Dr. Chris Bourke
cbourke@cse.unl.edu

Outline

1. Introduction
2. For loops
3. While loops
4. Other Loops & Issues
5. Pitfalls
6. Exercises

Part I: Introduction

Motivation & Introduction to Loop Control Structures

Motivation

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- Process data: apply an operation to each piece of data
- Repeat an operation until some condition is satisfied

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- Components of a loop

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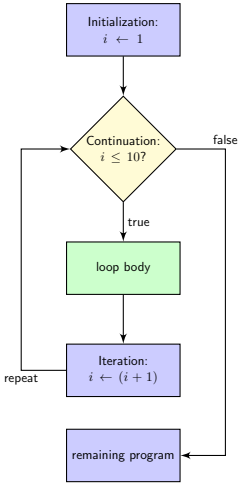
Termination Condition – negation of the continuation condition

Simple Example

Printout numbers 1 through 10:

1. Initialize a variable i to 1
2. While the variable i's value is less than or equal to 10...
3. Print i
4. Increment i by adding 1 to it
5. Go to step 2

Flow Diagram



Part II: For Loops

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- `i++` adds 1 to the variable `i`
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- "Equivalent" to `i = i + 1` and `i = i - 1`
- Honorable mention: prefix versions `++i` and `--i`

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- `a += 10;` adds 10 to the variable `a`
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- `a *= 2;` multiplies `a` by 2
- `a /= 3;` divides `a` by 3

More Examples


```
1  //print numbers 10, 20, 30, ... 100
2  int i;
3  for(i=10; i<=100; i+=10) {
4    printf("%d\n", i);
5  }
6  printf("%d\n", i);
7
8  int n = 10;
9  int sum = 0; //without initialization, no default value
10 for(i=1; i<n; i++) {
11   //sum = sum + i;
12   sum += i;
13 }
14 printf("sum of integers 1..%d = %d\n", n, sum);
```

Part III: While Loops

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- Same behavior: continuation condition is checked at the start of the loop

While Loops


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2  while(i <= 10) {
3    printf("i = %d\n", i);
4    i++;
5  }
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```

- Initialization is before and outside the loop structure
- `while` statement contains only the continuation condition
- Increment is done *inside* the loop body
- Take care: order inside the loop matters

While Loops


```
1  int i = 1;
2  while(i <= 10) {
3    i++;
4    printf("i = %d\n", i);
5  }
```

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- Any for loop can be rewritten as a while loop and vice versa
- Syntactic sugar, flexibility, variety
- Generally, the situation/context will inform how "natural" each loop is
- Use for loops when the number of iterations is known up front
- Use while loops when you don't know how many iterations will be executed/they may vary depending on the variable values

While Loop Scenario

Example: write a loop (or loops) to *normalize* a number:

$$89237.49283 \rightarrow 8.923749283 \times 10^4$$

$$321.321 \rightarrow 3.21321 \times 10^2$$

$$0.00432 \rightarrow 4.32 \times 10^{-3}$$

While Loop Scenario


```
1  double x = 89237.49283;
2  int counter = 0;
3  while(x > 10) {
4    x /= 10.0;
5    counter++;
6  }
7  printf("x = %f * 10^%d\n", x, counter);
8  while(x < 1) {
9    x *= 10.0;
10   counter--;
11 }
12 printf("x = %f * 10^%d\n", x, counter);
13 return 0;
```

Part IV: Other Issues & Types of Loops

Loop Variable Scoping

- For loop examples declared the iteration variable before the loop

```
1  int i;
2  for(i=0; i<=10; i++) {
3    ...
4  }
```

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- The *scope* of `i` lasted after the loop

Loop Variable Scoping

- Many modern languages and newer versions of C (C99) allow a loop-scoped variable declaration:

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1  for(int i=0; i<=10; i++) {
2    ...
3  }
```

- Scope of `i` is limited to the loop
- If you use this modern style, you must compile with:
  `gcc -std=c99` or
  `c99`

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1  int flag = 1;
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3    ...
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5      flag = 0;
6    }
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3    ...
4    if(<some complex logic>) {
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7  }
```

- Sometimes, people use `break` to break out instead:

```
1  while(1) {
2    ...
3    if(<some complex logic>) {
4      break;
5    }
6  }
```

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- Consequence: they always execute *at least once*
- Example:

```
1  int i = 0;
2  do {
3    i++;
4    print("i = %d\n", i);
5  } while(i < 10);
```

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- Example:

```
1  int i, j;
2  for(i=1; i<=10; i++) {
3    for(j=1; j<=10; j++) {
4      printf("%d\n", (i+j));
5    }
6  }
```

Part V: Pitfalls
Common Errors & Misconceptions

Consider the following code:

```
1  int i = 1;
2  while(i <= 10) {
3    printf("%d\n", i);
4  }
```

Pitfall
Improper Increment

Consider the following code:

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- There is no increment/progress toward the termination condition
- To kill a command line program: control-C

Pitfall
Misplaced Semicolon

Consider the following code:

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- Empty loop body

Consider the following code:

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Bad Coding Style

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- Always include curly brackets even if they are not necessary!

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- Zune Bug: December 31st, 2008
- Thousands of Zunes froze for 24 hours
- 2008 was a leap year: 366 days
- An embedded module in the Zune contained the following (actual) code

Zune Bug

What happened?


```
1  while(days > 365) {
2    if(IsLeapYear(year)) {
3      if(days > 366) {
4        days -= 366;
5        year += 1;
6      }
7    } else {
8      days -= 365;
9      year += 1;
10   }
11 }
```

Part VI: Exercises

Exercise

Write code snippets to do the following.

1. Print a list of even integers 0 to n, one to a line
2. The same list, but delimited by commas
3. A list of integers divisible by 3 between 10 and 100 (print a total as well)
4. Prints all positive powers of two, $1, 2, 4, 8, \ldots, 2^{30}$
5. Prints all even integers 2 thru 200 on 10 different lines (10 numbers per line) in reverse order
6. Prints the following pattern of numbers (hint: use some value of $i + 10j$):

```
11, 21, 31, 41, ..., 91, 101
12, 22, 32, 42, ..., 92, 102
...
20, 30, 40, 50, ..., 100, 110
```

Exercise

Write a FizzBuzz program: print numbers from 1 to 100, but for numbers that are multiples of 3 print “Fizz” instead. For numbers that are multiples of 5, print “Buzz” instead. For numbers that are multiples of both 3 and 5, print “FizzBuzz”

Exercise

Implement a program to use the Babylonian method to compute a square root of a number a using the series,

$$x_{n+1} = \frac{1}{2} \cdot \left(x_n + \frac{a}{x_n} \right), \quad x_0 = 1$$

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$$x_2 = \frac{1}{2} \cdot \left(x_1 + \frac{a}{x_1} \right)$$

$$x_2 = \frac{1}{2} \cdot \left(1.5 + \frac{2}{1.5} \right) = 1.41666$$

Exercise

Would you accept a job with the following conditions?

- You only get paid a dollar a month.
- However, each month your pay doubles.
- Your contract lasts 2 years.

Write a program to project your earnings.

Exercise

DogeCoin is 'sploding! It increases 20% in value every week! Suppose we start with 1000 DogeCoin which is initially worth \$10 (1 DogeCoin = 1 cent). Let's take the following strategy: at the end of each week, we sell half our gains, and keep the rest growing. Then, at the end of the year we'll report how much cash we have, how much DogeCoin we have, and how much that is worth in total USD.