ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

Εισαγωγή στον Προγραμματισμό
Introduction to Programming

Διάλεξη 10: Μορφοποίηση Εισόδου/Εξόδου

Γ. Παπαγιαννάκης

Ευρωπαϊκή Ένωση
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επένδυση στην κοινωνία της γνώσης
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ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ
Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

Άδειες Χρήσης

Χρηματοδότηση

- Το παρόν εκπαιδευτικό υλικό έχει αναπτυχθεί στα πλαίσια του εκπαιδευτικού έργου του διδάσκοντα.
- Το έργο «**Ανοικτά Ακαδημαϊκά Μαθήματα στο Πανεπιστήμιο Κρήτης**» έχει χρηματοδοτήσει μόνο τη αναδιαμόρφωση του εκπαιδευτικού υλικού.
- Το έργο υλοποιείται στο πλαίσιο του Επιχειρησιακού Προγράμματος «Εκπαίδευση και Δια Βίου Μάθηση» και συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση (Ευρωπαϊκό Κοινωνικό Ταμείο) και από εθνικούς πόρους.

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HY-150 Προγραμματισμός
CS-150 Programming

Lecture 10: Customizing I/O

G. Papagiannakis

Overview

- Input and output
- Numeric output
  - Integer
  - Floating point
- File modes
  - Binary I/O
  - Positioning
- String streams
- Line-oriented input
  - Character input
  - Character classification

Kinds of I/O

- Individual values
  - See Chapter 4, 10
- Streams
  - See Chapters 10-11
- Graphics and GUI
  - See Chapters 12-16
- Text
  - Type driven, formatted
  - Line oriented
  - Individual characters
- Numeric
  - Integer
  - Floating point
  - User-defined types

Type	Size in bits	Format	Value range	
			Approximate	Exact
character	8	signed (one's complement)	-127 to 127	
		signed (two's complement)	-128 to 127	
		unsigned	0 to 255	
integral	16	signed (one's complement)	$\pm 3.27 \cdot 10^4$	-32767 to 32767
		signed (two's complement)		-32768 to 32767
		unsigned	0 to $6.55 \cdot 10^4$	0 to 65535
	32	signed (one's complement)	$\pm 2.14 \cdot 10^9$	-2,147,483,647 to 2,147,483,647
		signed (two's complement)		-2,147,483,648 to 2,147,483,647
		unsigned	0 to $4.29 \cdot 10^9$	0 to 4,294,967,295
	64	signed (one's complement)	$\pm 9.22 \cdot 10^{18}$	-9,223,372,036,854,775,807 to 9,223,372,036,854,775,807
		signed (two's complement)		-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
		unsigned	0 to $1.84 \cdot 10^{19}$	0 to 18,446,744,073,709,551,615
floating point	32	IEEE-754	$\pm 3.4 \cdot 10^{\pm 38}$ (~7 digits)	• min subnormal: $\pm$ 1.401,298,4 $\cdot 10^{-47}$ • min normal: $\pm$ 1.175,494,3 $\cdot 10^{-38}$ • max: $\pm$ 3.402,823,4 $\cdot 10^{38}$
	64	IEEE-754	$\pm 1.7 \cdot 10^{\pm 308}$ (~15 digits)	• min subnormal: $\pm$ 4.940,656,458,412 $\cdot 10^{-324}$ • min normal: $\pm$ 2.225,073,858,507,201,4 $\cdot 10^{-308}$ • max: $\pm$ 1.797,693,134,862,315,7 $\cdot 10^{308}$

Observation

- As programmers we prefer regularity and simplicity
  - But, our job is to meet people's expectations
- People are very fussy/particular/picky about the way their output looks
  - They often have good reasons to be
  - Convention/tradition rules
    - What does 123,456 mean?
    - What does (123) mean?
  - The world (of output formats) is weirder than you could possibly imagine

Output formats

- Integer values
  - **1234** (decimal)
  - **2322** (octal)
  - **4d2** (hexadecimal)
- Floating point values
  - **1234.57** (general)
  - **1.2345678e+03** (scientific)
  - **1234.567890** (fixed)
- Precision

(for floating-point values)
  - **1234.57** (precision 6)
  - **1234.6** (precision 5)
- Fields
  - **|12|** (default for **|** followed by **12** followed by **|**)
  - **| 12|** (**12** in a field of 4 characters)

Numerical Base Output

- You can change "base"
  - Base 10 == decimal; digits: 0 1 2 3 4 5 6 7 8 9
  - Base 8 == octal; digits: 0 1 2 3 4 5 6 7
  - Base 16 == hexadecimal; digits: 0 1 2 3 4 5 6 7 8 9 a b c d e f

```
// simple test:
        cout << dec << 1234 << "\t(decimal)\n"
                << hex << 1234 << "\t(hexadecimal)\n"
                << oct << 1234 << "\t(octal)\n";
// The '\t' character is "tab" (short for "tabulation character")

// results:
    1234        (decimal)
    4d2         (hexadecimal)
    2322        (octal)
```

“Sticky” Manipulators

- You can change “base”
  - Base 10 == decimal; digits: 0 1 2 3 4 5 6 7 8 9
  - Base 8 == octal; digits: 0 1 2 3 4 5 6 7
  - Base 16 == hexadecimal; digits: 0 1 2 3 4 5 6 7 8 9 a b c d e f

```
// simple test:
cout << 1234 << '\t'
             << hex << 1234 << '\t'
             << oct << 1234 << '\n';
cout << 1234 << '\n';        // the octal base is still in effect

// results:
1234    4d2    2322
2322
```

Other Manipulators

- You can change "base"
  - Base 10 == decimal; digits: 0 1 2 3 4 5 6 7 8 9
  - Base 8 == octal; digits: 0 1 2 3 4 5 6 7
  - Base 16 == hexadecimal; digits: 0 1 2 3 4 5 6 7 8 9 a b c d e f

```
// simple test:
    cout << 1234 << '\t'
              << hex << 1234 << '\t'
              << oct << 1234 << endl;          // '\n'
    cout << showbase << dec;     // show bases
    cout << 1234 << '\t'
              << hex << 1234 << '\t'
              << oct << 1234 << '\n';
// results:
    1234        4d2      2322
    1234        0x4d2    02322
```

Floating-point Manipulators

- You can change floating-point output format
  - general – **iostream** chooses best format using **n** digits (this is the default)
  - **scientific** – one digit before the decimal point plus exponent; **n** digits after **.**
  - **fixed** – no exponent; **n** digits after the decimal point

```
// simple test:
cout << 1234.56789 << "\t\t(general)\n"//  \t\t  to line up columns
        << fixed << 1234.56789 << "\t(fixed)\n"
        << scientific << 1234.56789 << "\t(scientific)\n";

// results:
1234.57            (general)
1234.567890        (fixed)
1.234568e+003      (scientific)
```

Precision Manipulator

- Precision (the default is 6)
  - general – precision is the number of digits
    - Note: the **general** manipulator is not standard, just in std_lib_facilities.h
  - **scientific** – precision is the number of digits after the . (dot)
  - **fixed** – precision is the number of digits after the . (dot)

// example:

```
cout << 1234.56789 << '\t' << fixed << 1234.56789 << '\t'
        << scientific << 1234.56789 << '\n';
cout << general << setprecision(5)
        << 1234.56789 << '\t' << fixed << 1234.56789 << '\t'
        << scientific << 1234.56789 << '\n';
cout << general << setprecision(8)
        << 1234.56789 << '\t' << fixed << 1234.56789 << '\t'
        << scientific << 1234.56789 << '\n';
```

// results (note the rounding):

```
1234.57       1234.567890      1.234568e+003
1234.6        1234.56789       1.23457e+003
1234.5679     1234.56789000    1.23456789e+003
```

Output field width

A width is the number of characters to be used for the next output operation

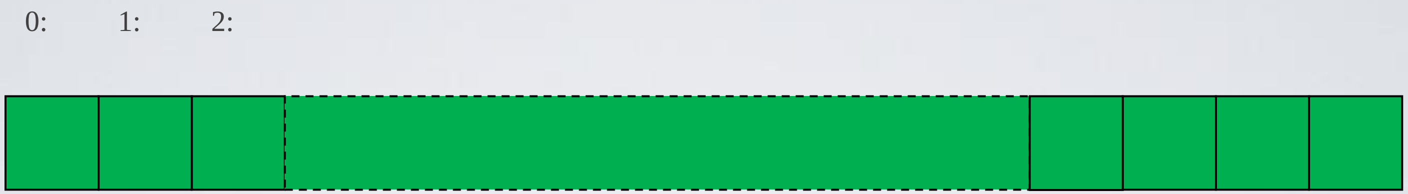
- Beware: width applies to next output only (it doesn't "stick" like precision, base, and floating-point format)
- Beware: output is never truncated to fit into field
  - (better a bad format than a bad value)

```
// example:
    cout << 123456 <<'|'<< setw(4) << 123456 << '|'
            << setw(8) << 123456 << '|' << 123456 << "|\n";
    cout << 1234.56 <<'|'<< setw(4) << 1234.56 << '|'
            << setw(8) << 1234.56 << '|' << 1234.56 << "|\n";
    cout << "asdfgh" <<'|'<< setw(4) << "asdfgh" << '|'
            << setw(8) << "asdfgh" << '|' << "asdfgh" << "|\n";
// results:
    123456|123456|  123456|123456|
    1234.56|1234.56| 1234.56|1234.56|
    asdfgh|asdfgh|  asdfgh|asdfgh|
```

Observation

- This kind of detail is what you need textbooks, manuals, references, online support, etc. for
  - You **always** forget some of the details when you need them

A file



- At the fundamental level, a file is a sequence of bytes numbered from 0 upwards
- Other notions can be supplied by programs that interpret a “file format”
  - For example, the 6 bytes "123.45" might be interpreted as the floating-point number 123.45

File open modes

- By default, an **ifstream** opens its file for reading
- By default, an **ofstream** opens its file for writing.
- Alternatives:
  - **ios_base::app** *// append (i.e., add to the end of the file)*
  - **ios_base::ate** *// "at end" (open and seek to end)*
  - **ios_base::binary** *// binary mode – beware of system specific behavior*
  - **ios_base::in** *// for reading*
  - **ios_base::out** *// for writing*
  - **ios_base::trunc** *// truncate file to 0-length*
- A file mode is optionally specified after the name of the file:
  - **ofstream of1(name1);** *// defaults to ios_base::out*
  - **ifstream if1(name2);** *// defaults to ios_base::in*
  - **ofstream ofs(name, ios_base::app);** *// append rather than overwrite*
  - **fstream fs("myfile", ios_base::in|ios_base::out);** *// both in and out*

Text vs. binary files

123 as characters:

12345 as characters:

123 as binary:

12345 as binary:

123456 as characters:

123 456 as characters:

In binary files, we use sizes to delimit values

In text files, we use separation/termination characters

Text vs. binary

- Use text when you can
  - You can read it (without a fancy program)
  - You can debug your programs more easily
  - Text is portable across different systems
  - Most information can be represented reasonably as text
- Use binary when you must
  - E.g. image files, sound files

Binary files

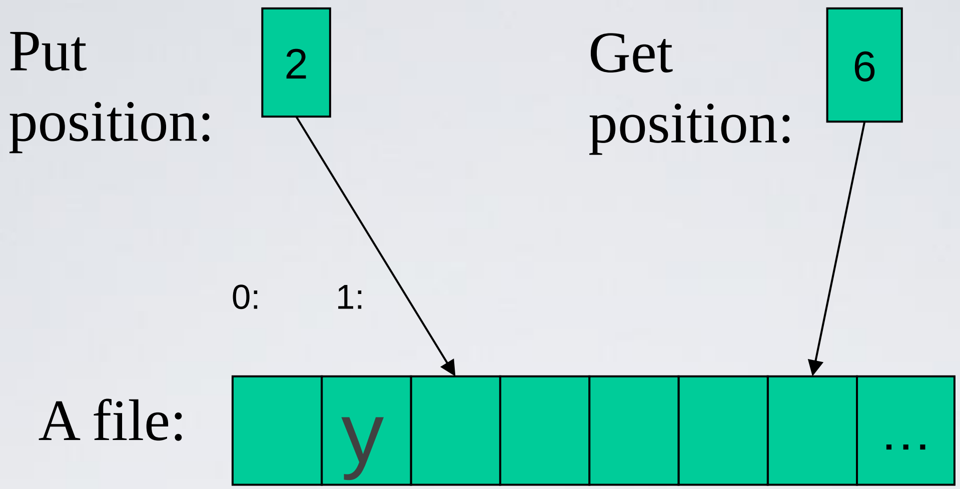
```
int main()
    // use binary input and output
{
    cout << "Please enter input file name\n";
    string name;
    cin >> name;
    ifstream ifs(name.c_str(),ios_base::binary);        // note: binary
    if (!ifs) error("can't open input file ", name);

    cout << "Please enter output file name\n";
    cin >> name;
    ofstream ofs(name.c_str(),ios_base::binary);        // note: binary
    if (!ofs) error("can't open output file ",name);

    // "binary" tells the stream not to try anything clever with the bytes
```

Binary files

```
vector<int> v;

// read from binary file:
int i;
while (ifs.read(as_bytes(i),sizeof(int)))          // note: reading bytes
        v.push_back(i);

// ... do something with v ...

// write to binary file:
for(int i=0; i<v.size(); ++i)
        ofs.write(as_bytes(v[i]),sizeof(int));     // note: writing bytes
return 0;
}
```

*// for now, treat **as_bytes()** as a primitive*

Positioning in a filestream




```
fstream fs(name.c_str());            // open for input and output

// …
fs.seekg(5);      // move reading position ('g' for 'get') to 5 (the 6th character)
char ch;
fs>>ch;           // read and increment reading position
cout << "character[6] is " << ch << '(' << int(ch) << ")\n";
fs.seekp(1);      // move writing position ('p' for 'put') to 1 (the 2nd character)
fs<<'y';          // write and increment writing position
```

Positioning

- Whenever you can
  - Use simple streaming
    - Streams/streaming is a very powerful metaphor
    - Write most of your code in terms of "plain" **istream** and **ostream**
  - Positioning is far more error-prone
    - Handling of the end of file position is system dependent and basically unchecked

String streams

A **stringstream** reads/writes from/to a **string** rather than a file or a keyboard/screen

```
double str_to_double(string s)
        // if possible, convert characters in s to floating-point value
{
   istringstream is(s);      // make a stream so that we can read from s
   double d;
   is >> d;
   if (!is) error("double format error");
   return d;
}

double d1 = str_to_double("12.4");                     // testing
double d2 = str_to_double("1.34e-3");
double d3 = str_to_double("twelve point three");   // will call error()
```

String streams

- Very useful for
  - formatting into a fixed-sized space (think GUI)
  - for extracting typed objects out of a string

Type vs. line

- Read a string

```
string name;
cin >> name;                    // input: Dennis Ritchie
cout << name << '\n';           // output: Dennis
```

- Read a line

```
string name;
getline(cin,name);   // input: Dennis Ritchie
cout << name << '\n';           // output: Dennis Ritchie
// now what?
// maybe:
istringstream ss(name);
ss>>first_name;
ss>>second_name;
```

Characters

- You can also read individual characters

```
char ch;
while (cin>>ch) {        // read into ch, skipping whitespace characters
   if (isalpha(ch)) {
                  // do something
   }
}

while (cin.get(ch)) {    // read into ch, don't skip whitespace characters
   if (isspace(ch)) {
                  // do something
   }
   else if (isalpha(ch)) {
                  // do something else
   }
}
```

Character classification functions

- If you use character input, you often need one or more of these (from header **<cctype>**):

  - **isspace(c)** *// is **c** whitespace? (' ', '\t', '\n', etc.)*
  - **isalpha(c)** *// is **c** a letter? ('a'..'z', 'A'..'Z') note: not '_'*
  - **isdigit(c)** *// is **c** a decimal digit? ('0'.. '9')*
  - **isupper(c)** *// is **c** an upper case letter?*
  - **islower(c)** *// is **c** a lower case letter?*
  - **isalnum(c)** *// is **c** a letter or a decimal digit?*

Line-oriented input

- Prefer >> to **getline()**
  - i.e. avoid line-oriented input when you can

- People often use **getline()** because they see no alternative
  - But it often gets messy

- When trying to use **getline()**, you often end up
  - using >> to parse the line from a **stringstream**
  - using **get()** to read individual characters

Next lecture

- Graphical output
  - Creating a GUI window with various figures
  - Drawing graphs

Acknowledgements

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http://www.stroustrup.com/Programming/

Thank you!

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