CS 103 Unit 13 Slides

C++ References

Mark Redekopp
Swap Two Variables

- Classic example of issues with local variables:
  - Write a function to swap two variables
- Pass-by-value doesn’t work
  - Copy is made of x,y from main and passed to x,y of swapit...Swap is performed on the copies
- Pass-by-reference (pointers) does work
  - Addresses of the actual x,y variables in main are passed
  - Use those address to change those physical memory locations

```cpp
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y=" << x << "," << y << endl;
}

void swapit(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

Program output: x=5,y=7

```cpp
int main()
{
    int x=5, y=7;
    swapit(&x, &y);
    cout <<"x,y=" << x << "," << y << endl;
}

void swapit(int *x, int *y)
{
    int temp;
    temp = *x;
    *x = *y;
    *y = temp;
}
```

Program output: x=7,y=5
C++ Reference Variables

• So you want a function to actually modify a variable from another function but you don’t like pointers and they confuse you?
  – Too bad. Don’t give up!
    You CAN understand pointers...keep working at it
  – BUT...
   – You can also use C++ Reference variables

• C++ reference variables essentially pass arguments via pointer/address but use the syntax of pass-by-value (i.e. no more de-referencing)
Using C++ Reference Variables

• To declare a reference variable, use the ‘&’ operator in a declaration!
  – Poor choice by C++ because it is confusing since ‘&’ is already used for the ‘address of operator’ when used in an expression (i.e. non-declaration)
• Behind the scenes the compiler will essentially access variable with a pointer
• But you get to access it like a normal variable without dereferencing
• Think of a reference variable as an alias

Using pointers

```
int main()
{
    int y = 3;
    doit(&y); //address-of oper.
    cout << y << endl;
    return 0;
}
```

```
int doit(int *x)
{
    *x = *x - 1;
    return *x;
}
```

Using C++ References

```
int main()
{
    int y = 3;
    doit(&y); //Ref. dec.
    cout << y << endl;
    return 0;
}
```

```
int doit(int &x) // Ref. dec.
{
    x = x - 1;
    return x;
}
```

Output: ‘2’ in both programs
Swap Two Variables

- **Pass-by-value** => Passes a copy
- **Pass-by-reference** =>
  - **Pass-by-pointer/address** => Passes address of actual variable
  - **Pass-by-reference** => Passes an alias to actual variable

```c
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y="<< x<<","<< y;
    cout << endl;
}

void swapit(int x, int y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

**program output:** x=5, y=7

```c
int main()
{
    int x=5, y=7;
    swapit(&x, &y);
    cout <<"x,y="<< x<<","<< y;
    cout << endl;
}

void swapit(int *x, int *y)
{
    int temp;
    temp = *x;
    *x = *y;
    *y = temp;
}
```

**program output:** x=7, y=5

```c
int main()
{
    int x=5, y=7;
    swapit(x, y);
    cout <<"x,y="<< x<<","<< y;
    cout << endl;
}

void swapit(int &x, int &y)
{
    int temp;
    temp = x;
    x = y;
    y = temp;
}
```

**program output:** x=7, y=5
When to Use References

• Whenever you want to actually modify an input parameter/argument (i.e. a local variable from another function)

• Great for passing big struct or class objects
  – Because no copy will be made, (pass-by-value would have wasted time copying contents to new memory)
**Const arguments**

- An aside:
  - If we want an extra safety precaution for our own mistakes, we can declare arguments as 'const'
  - The compiler will produce an error to tell you that you have written code that will modify the object you said should be constant
  - Doesn’t protect against backdoors like pointers that somehow point at these data objects.

```cpp
class GradeBook{
    public:
        int grades[8][100];
};

int main()
{
    GradeBook gb;
    ...
    double average = process_it(gb);
    return 0;
}

double process_it(const GradeBook &mygb)
{
    double sum = 0;
    for(int i=0; i < 8; i++)
        for(int j=0; j < 100; j++)
            sum += mygb.grades[i][j];

    mygb.grades[0][0] = 91;
    // modification of mygb
    // compiler will produce ERROR!

    sum /= (8*100);
    return sum;
}
```
Vector/Deque/String Suggestions

- When you pass a vector, deque, or even C++ string to a function a deep copy will be made which takes time.
- Copies may be desirable in a situation to make sure the function alter your copy of the vector/deque/string.
- But passing by \texttt{const} reference saves time and provide the same security.

```cpp
#include <iostream>
#include <vector>
using namespace std;

int main()
{
    vector<int> my_vec;
    for(int i=0; i < 5; i++){
        my_vec.push_back(i+50); // doesn’t work
    }

    // can myvec be different upon return?
    do_something1(my_vec);

    // can myvec be different upon return?
    do_something2(my_vec);
    return 0;
}

void do_something1(vector<int> v)
{
    // process v;
}

void do_something2(const vector<int>& v)
{
    // process v;
}
```
Reference Gotchas!

- Returning a reference to a dead variable (i.e. a local variable of a function that just completed)
- avg was a local variable and thus was deallocated when process_it completed

```cpp
class GradeBook{
  public:
    int grades[8][100];
};

int main()
{
  GradeBook gb;
  double& average = process_it(gb);
  cout << "Avg: " << average << endl;
  // Possible seg. fault / prog. crash
  return 0;
}

double &process_it(const GradeBook &mygb)
{
  double avg = 0;
  for(int i=0; i < 8; i++)
    for(int j=0; j < 100; j++)
      avg += mygb.grades[i][j];

  avg /= (8*100);
  return avg; // reference to avg is returned...
}
```
MORE C++ REFERENCE FACTS
Using C++ References

- Mainly used for parameters, but can use it within the same function
- A variable declared with an ‘int &’ doesn’t store an int, but stores a reference/alias for an actual integer
- MUST assign to the reference variable when you declare it.

```cpp
text
```