

Objects and classes, advanced topics

Victor Eijkhout, Susan Lindsey

Fall 2023

last formatted: October 24, 2023

1. Direct alteration of internals

Return a reference to a private member:

```
1 class Point {  
2 private:  
3     double x,y;  
4 public:  
5     double &x_component() { return x; };  
6 };  
7 int main() {  
8     Point v;  
9     v.x_component() = 3.1;  
10 }
```

Only define this if you need to be able to alter the internal entity.

2. Reference to internals

Returning a reference saves you on copying.

Prevent unwanted changes by using a 'const reference'.

```
1 class Grid {
2 private:
3     vector<Point> thepoints;
4 public:
5     const vector<Point> &points() const {
6         return thepoints; };
7 };
8 int main() {
9     Grid grid;
10    cout << grid.points()[0];
11    // grid.points()[0] = whatever ILLEGAL
12 }
```

3. Access gone wrong

We make a class for points on the unit circle

```
1 // object/unit.cpp
2 class UnitCirclePoint {
3 private:
4     float x,y;
5 public:
6     UnitCirclePoint(float x) {
7         setx(x); };
8     void setx(float newx) {
9         x = newx; y = sqrt(1-x*x);
10    };
```

You don't want to be able to change just one of x,y !
In general: enforce invariants on the members.

4. Const functions

A function can be marked as const:
it does not alter class data,
only changes are through return and parameters

5. 'this' pointer to the current object

```
1 class MyClass {  
2 private:  
3     int myint;  
4 public:  
5     MyClass(int myint) {  
6         this->myint = myint; // `this' redundant!  
7     };  
8 };
```

6. 'this' use

You don't often need the `this` pointer. Example: you need to call a function inside a method that needs the object as argument)

```
1 /* forward definition: */ class someclass;
2 void somefunction(const someclass &c) {
3     /* ... */ }
4 class someclass {
5     // method:
6     void somemethod() {
7         somefunction(*this);
8     };
```

(Rare use of dereference star)

Operator overloading

7. Operator overloading

Syntax:

<returntype> **operator**<op>(<argument>) { <definition> }

For instance:

Code:

```
1 // geom/pointscale.cpp
2 Point Point::operator*(double f) {
3     return Point(f*x,f*y);
4 };
5     /* ... */
6 cout << "p1 to origin "
7     << p1.dist_to_origin() <<
8     '\n';
9     Point scale2r = p1*2.;
10    cout << "scaled right: "
11        << scale2r.dist_to_origin()
12        << '\n';
13    // ILLEGAL Point scale2l = 2.*p1;
```

Output:

```
p1 to origin 2.23607
scaled right: 4.47214
```

Exercise 1

Revisit exercise ?? and replace the *add* and *scale* functions by overloaded operators.

Hint: for the *add* function you may need `'this'`.

8. Constructors and contained classes

Finally, if a class contains objects of another class,

```
1 class Inner {  
2 public:  
3     Inner(int i) { /* ... */ }  
4 };  
5 class Outer {  
6 private:  
7     Inner contained;  
8 public:  
9 };
```

9. When are contained objects created?

```
Outer( int n ) {  
    contained = Inner(n);  
};
```

1. This first calls the default constructor
2. then calls the *Inner(n)* constructor,
3. then copies the result over the *contained* member.

```
Outer( int n )  
    : contained(Inner(n)) {  
    /* ... */  
};
```

1. This creates the *Inner(n)* object,
2. placed it in the *contained* member,
3. does the rest of the constructor, if any.

10. Copy constructor

- Default defined copy and 'copy assignment' constructors:

```
some_object x(data);  
some_object y = x;  
some_object z(x);
```

- They copy an object:
 - simple data, including pointers
 - included objects recursively.
- You can redefine them as needed.

```
1 // object/copyscalar.cpp  
2 class has_int {  
3 private:  
4     int mine{1};  
5 public:  
6     has_int(int v) {  
7         cout << "set: " << v  
8             << '\n';  
9         mine = v; };  
10    has_int( has_int &h ) {  
11        auto v = h.mine;  
12        cout << "copy: " << v  
13            << '\n';  
14        mine = v; };  
15    void printme() {  
16        cout << "I have: " << mine  
17            << '\n'; };  
18 };
```

11. Copy constructor in action

Code:

```
1 // object/copyscalar.cpp
2 has_int an_int(5);
3 has_int other_int(an_int);
4 an_int.printme();
5 other_int.printme();
6 has_int yet_other = other_int;
7 yet_other.printme();
```

Output:

```
set: 5
copy: 5
I have: 5
I have: 5
copy: 5
I have: 5
```

12. Copying is recursive

Class with a vector:

```
1 // object/copyvector.cpp
2 class has_vector {
3 private:
4     vector<int> myvector;
5 public:
6     has_vector(int v) { myvector.push_back(v); };
7     void set(int v) { myvector.at(0) = v; };
8     void printme() { cout
9         << "I have: " << myvector.at(0) << '\n'; };
10 };
```

Copying is recursive, so the copy has its own vector:

Code:

```
1 // object/copyvector.cpp
2 has_vector a_vector(5);
3 has_vector other_vector(a_vector);
4 a_vector.set(3);
5 a_vector.printme();
6 other_vector.printme();
```

Output:

```
I have: 3
I have: 5
```

13. Destructor

- Every class *myclass* has a *destructor* *~myclass* defined by default.

- The default destructor does nothing:

```
~myclass() {};
```

- A destructor is called when the object goes out of scope.
Great way to prevent memory leaks: dynamic data can be released in the destructor. Also: closing files.

14. Destructor example

Just for tracing, constructor and destructor do `cout`:

```
1 // object/destructor.cpp
2 class SomeObject {
3 public:
4     SomeObject() {
5         cout << "calling the constructor"
6             << '\n';
7     };
8     ~SomeObject() {
9         cout << "calling the destructor"
10            << '\n';
11     };
12 };
```

15. Destructor example

Destructor called implicitly:

Code:

```
1 // object/destructor.cpp
2 cout << "Before the nested scope"
3     << '\n';
4 {
5     SomeObject obj;
6     cout << "Inside the nested
7         scope"
8         << '\n';
9 }
10 cout << "After the nested scope"
11     << '\n';
```

Output:

*Before the nested scope
calling the constructor
Inside the nested scope
calling the destructor
After the nested scope*

Headers

16. C headers plusplus

You know how to use `.h` files in C.

Classes in C++ need some extra syntax.

17. Data members in proto

Data members, even private ones, need to be in the header file:

```
1 class something {  
2 private:  
3   int localvar;  
4 public:  
5   // declaration:  
6   double somedo(vector);  
7 };
```

Implementation file:

```
1 // definition  
2 double something::somedo(vector v) {  
3   .... something with v ....  
4   .... something with localvar ....  
5 };
```

18. Static class members

A static member acts as if it's shared between all objects.

(Note: C++17 syntax)

Code:

```
1 // link/static17.cpp
2 class myclass {
3 private:
4     static inline int count=0;
5 public:
6     myclass() { ++count; };
7     int create_count() {
8         return count; };
9 };
10      /* ... */
11 myclass obj1,obj2;
12 cout << "I have defined "
13      << obj1.create_count()
14      << " objects" << '\n';
```

Output:

I have defined 2 objects

19. Static class members, C++11 syntax

```
1 // link/static.cpp
2 class myclass {
3 private:
4     static int count;
5 public:
6     myclass() { ++count; };
7     int create_count() { return count; };
8 };
9     /* ... */
10 // in main program
11 int myclass::count=0;
```