

COMP140: Creative Computing: Codecraft

4: Inheritance and Polymorphism

Learning outcomes

- ▶ **Understand** Inheritance in Object Orientated Programming
- ▶ **Understand** Polymorphism role in creating Games
- ▶ **Apply** your knowledge of Inheritance and Polymorphism to programming problems

Classes Review

Classes

- ▶ Let us look at Classes again
- ▶ Classes allow us to create our own data types
- ▶ They consist of a series of data(variables) and functions that operate on the data
- ▶ Functions and variables inside the class can be marked with the following **access specifiers**
 - ▶ **Public**: Can be accessed directly
 - ▶ **Private**: Can only be accessed inside the class
 - ▶ **Protected**: Acts like private, but child classes can access

Class Examples

```
class Player
{
public:
    Player()
    {
        Health=100;
    };

    void TakeDamage(int health)
    {
        Health-=health;
    };

    void HealDamage(int health)
    {
        Health+=health;
    };

    ~Player() {};
private:
    int Health;
};
```

Classes vs Structs

- ▶ A **Struct** is pretty much the same as a **Class**
- ▶ The only difference in functionality, by default:
 - ▶ Everything in a **Class** is **private**
 - ▶ Everything in a **Struct** is **public**
- ▶ Difference by convention:
 - ▶ Structs are used for holding related data and tend not to have functions
 - ▶ Classes hold data and functions

Creating an Instance

```
//Creating on the stack, this will be deleted when it drops out of scope
Player player1=Player();

//Call take damage function, notice we use . to access functions
player.TakeDamage(20);

//Creating on the Heap, please delete!!
Player * player2=new Player();

//Call take damage function, note we use -> to access functions
player->TakeDamage(20);

//Deleting player2 on the heap
if (player2)
{
    delete player2;
    player2=nullptr;
}
```

Constructor & Destructor

- ▶ **Constructors** are called when you create an instance
- ▶ Constructors can take in zero or many parameters
- ▶ You need to declare different version of the constructor
- ▶ Destructors are called when the instance has been deleted (by the dropping out of scope, or explicitly deleted in C++)
- ▶ Constructors have to be names the same as the class
- ▶ Destructors have the same name as the class but prefixed with ~ (tilde symbol)

Constructors

```
//Create a player  
Player * player1=new Player();  
  
//Create another player with the one parameter constructor  
Player player2=Player(10);  
  
//Create another player with the two parameter constructor  
Player * player3=new Player(100,20);  
  
delete player1;  
delete player2;
```

Using Constructors

```
//Create a player with the default no parameter constructor  
Player player1=new Player();
```

```
//Create a player with one parameter constructor  
Player player2=new Player(50);
```

```
//Create a player with two parameters constructor  
Player player3=new Player(120,50);
```

Encapsulation

- ▶ In OOP, Encapsulation is a key principle
- ▶ This refers to the idea that all data in a class should be hidden by the caller
- ▶ This means that **all** variables should be marked **private** or **protected**
- ▶ And only functions inside the class can operate on the data

Encapsulation Examples

```
class Player
{
    //see class above

    void TakeDamage(int health)
    {
        Health-=health;
        if (Health>0)
        {
            Kill()
        }
    };

    void Kill()
    {
        //Mark for deletion
        //remove from screen
    };
};
```

Inheritance

Introduction to Inheritance

- ▶ One of the key features of OOP languages is **Inheritance**
- ▶ This allows you to **Derive** a new class from an existing one
- ▶ When this is done, the new class automatically inherits the variables and functions of the **parent** class
- ▶ Advantages of inheritance includes
 - ▶ **Code reuse:** There is no need to redefine functionality, you can just inherit from a base class
 - ▶ **Fewer errors:** If you build on existing class that is bug free then you are more likely to have less errors
 - ▶ **Cleaner code:** because of the increase of code reuse then your code is more modular and reusable.

Inheritance Example

```
public class Enemy
{
    public:
        Enemy()
        {
            Damage=1;
        };

        virtual ~Enemy()
        {
        }

        void Attack()
        {
            std::cout<<"The attack causes "<<Damage<<" damage"<<std::endl;
        }
    protected:
        int Damage;
}
```

Inheritance Example

```
public class Boss : public Enemy
{
    public:
        Boss()
        {
            Damage=5;
            DamageMultiplier=2;
        };

        ~Boss()
        {
        }

        void SpecialAttack()
        {
            int totalDamage=Damage*DamageMultiplier;
            std::cout<<"Special attack causes "<<totalDamage<<" damage"<<std::endl;
        }

    protected:
        int DamageMultiplier;
}
}
```


Overriding

- ▶ You can override functions in the base class by providing a new version of the function
- ▶ You should mark any function that you are going to override with the **virtual** keyword
- ▶ Then in the child class, you have a function with the same signature which is marked with the **override** keyword

Overriding Example

```
public class Enemy
{
public:
    Enemy()
    {
        Damage=1;
    };

    //Make sure you mark any base class deconstructor as virtual!
    virtual ~Enemy()
    {
    }

    virtual void Attack()
    {
        std::cout<<"The attack causes "<<Damage<<" damage"<<std::endl;
    }
protected:
    int Damage;
}
```

Overriding Example

```
public class Boss : public Enemy
{
public:
    Boss()
    {
        Damage=5;
    };

    ~Boss()
    {
    }

    void Attack() override
    {
        Enemy::Attack();
        Damage+=1;
        std::cout<<"This is the boss attacking"<<std::endl;
    }
protected:
    int DamageMultiplier;
}
```

Polymorphism

Introduction to Polymorphism

- ▶ Polymorphism is another key feature of OOP languages
- ▶ The basic idea is that instances of a derived class can be treated as objects of the basic class
- ▶ They can be used as parameters for functions and in collections
- ▶ We then call the functions on these objects and our code will call the 'correct' version of the function
- ▶ This is best illustrated by an example

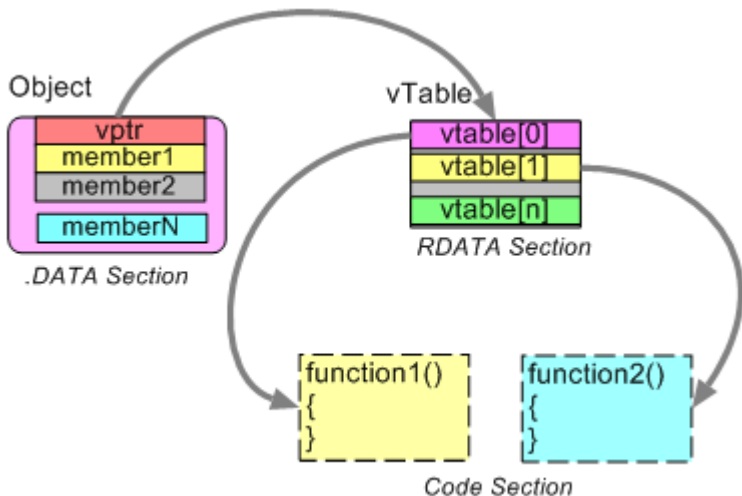
Polymorphism example

```
class Enemy{/*This has been defined in previous slides*/}  
class Boss : Enemy{/*Again see previou slides*/}  
  
//This Function is called by any enemy to carry out an attack  
void DoAttacks(Enemy *enemy)  
{  
    enemy->Attack();  
}  
  
//We probably have grabbed these from other game objects  
Enemy goblin=new Enemy();  
Enemy orc=new Enemy();  
Boss ogre=new Boss();  
  
//Call DoAttack on each one of these  
DoAttack(goblin);  
DoAttack(orc);  
DoAttack(ogre);
```

Polymorphism: Some details

- ▶ This is known as runtime Polymorphism and it works by making use of a construct called a virtual function table (a.k.a vtable)
- ▶ A compiler builds up a vtable during compilation
- ▶ Basically a hidden pointer to the vtable is added to the object and is used to call the correct version of the function
- ▶ Another thing to note, this has a cost so please don't overuse Polymorphism!

Vtable



Abstract Classes & Interfaces

- ▶ An **Abstract Class** is a class which cannot be initialised but is intended to be used as a base class
- ▶ It will have at least one function marked as pure virtual (see example)
- ▶ If you then inherit from an abstract class, you have to provide an implementation of all pure virtual functions

Abstract Classes & Interfaces

- ▶ An **Interface** is very similar to an abstract class, the only difference is that every function in an Interface is marked as pure virtual
- ▶ If you then inherit from an interface, you have to provide an implementation of all pure virtual functions

Abstract Class

```
class BaseEnemy
{
public:
    //Make sure we have a destructor defined!
    virtual ~BaseEnemy(){};
    virtual void Attack()=0;
    void Jump()
    {
        //Do jump code
    };
}

class Orc : public BaseEnemy
{
public:
    //we have to implement attack but no need to implement Jump
    void Attack()
    {
        //do attack
    }
}
```

Interface Example

```
class IJump
{
public:
    //We must provide a virtual destructor
    virtual ~Jump() {};
    void DoJump()=0;
}

class IAttack
{
public:
    virtual ~Attack() {};
    void DoAttack()=0;
}

class Orc : public IJump, public IAttack
{
    //we have to implement Attack and Jump Interface
public:
    void DoAttack()
    {
        //do attack
    }

    void DoJump()
    {
        //do Jump
    }
}
```

Interface Discussion

- ▶ You can think of an Interface as a contract
- ▶ The derived class must implement the Interface's function
- ▶ We can leverage Polymorphism to work with interfaces
- ▶ This means that I can consume derived classes in a function that takes in pointers to the Interface

Interface Discussion

- ▶ Lastly, Interfaces a great tool for working with others. We as a group could create the interface together
- ▶ Then another programmer can write Classes which implement the Interface
- ▶ While another writes code which consumes instances of the Interface
- ▶ `https://stackoverflow.com/questions/4456424/what-do-programmers-mean-when-they-say-code-aga`

Coffee Break

Exercise

Exercise 1 - Inheritance

- ▶ Please use one of the following projects as a starting point
 - ▶ C++ - <https://github.com/Falmouth-Games-Academy/COMP140-Exercises>
- ▶ You are creating an Fantasy RPG create a class hierarchy which represented the following Ranged Enemies, Melee Enemies, Healer Enemies
- ▶ Implement some functions for these classes
- ▶ Have you consider having a common base class?

Exercise 2 - Polymorphism

- ▶ Now add a pure virtual attack function to the base class
- ▶ Change how attack is implemented in each derived class

References

- ▶ Dawson, M. Beginning C++ through game programming 4th Ed. Chapter 8 - 10
<http://voyager.falmouth.ac.uk/vwebv/holdingsInfo?bibId=1097178>
- ▶ <https://www.geeksforgeeks.org/inheritance-in-c/>
- ▶ <https://www.geeksforgeeks.org/pure-virtual-functions-and-abstract-classes/>