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

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Classes Review

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  - **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;
};
```

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  - Structs are used for holding related data and tend not to have functions

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  - 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 & Deconstructor

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- Constructors have to be names the same as the class
- Deconstructors have the same name as the class but prefixed with $\sim$ (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 parametes constructor
Player player3=new Player(120,50);
```

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- 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

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  - **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;


}
```

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- 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 deconstuctor as virtual!
    virtual ~Enemy()
    {
    }

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

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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

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- 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
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- 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();
Eneny orc=new Enemy();
Boss ogre=new Boss();

//Call DoAttack on each one of these
DoAttack(goblin);
DoAttack(orc);
DoAttack(ogre);
```

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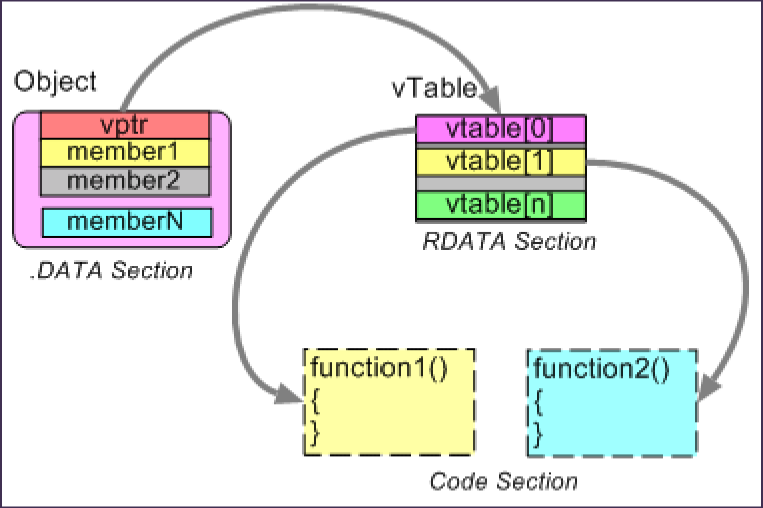
- This is know as runtime Polymorphism and it works by making use of a construct called a virtual function table (a.k.a vtable)
- A compiler builds up a vtable during compilation
- Basically a hidden pointer to the vtable is added to the object and is used to call the correct version of the function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

Vtable



Object
vptr
member1
member2
memberN
.DATA Section
vTable
vtable[0]
vtable[1]
vtable[n]
RDATA Section
function1()
{
}
function2()
{
}
Code Section

Abstract Classes & Interfaces

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- If you then inherit from an abstract class, you have to provide an implementation of all pure virtual functions

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- 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 deconstructor 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 deconstructor
    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
    }
}
```

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- 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

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- 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`

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Coffee Break

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Exercise

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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?

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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/`