DIGITAL ARTS & ENTERTAINMENT

Command & Pimpl

howest
university of applied sciences

Meltem Ozcelik (Concept: Amandine Gerard) / Daniil Shashenkov (Concept: Tooth Wu) / Joao Desager (Concept: Tan Zhi Hui)

Input

Remember we discussed the game loop

```
bool do_continue = true;
while(do_continue)
{
  do_continue = process_input();
  update();
  render();
}
```

We discussed that `update()`, `render()` is covered in Graphics Programming 1 & 2.

Today we discuss `process_input()`

Input

Comes from all kinds of devices

- Digital buttons
  - Down or Up, 0 or 1, circuit is open or closed.
- Analog Axes/Buttons
  - Range of values
    - Thumb RX -32768 -> 32768 (Xbox)
    - Trigger R 0 -> 255 (Xbox)
- Relative Axis
  - No defined center point, so no range possible
  - Delta position values (mouse for example)
- Accelerometers
  - Delta acceleration values (Wiimote, or VR controllers for example)
- Touch
  - Pressure ranges

Input polling

One way to process input is via "polling"

- Periodically read the current state of the device
  - Periodically: once per frame in our example
- Often game pads, joysticks
- On windows, this is what the Xinput API provides
  - `XInputGetState()`

    We'll use this in the exercises and our engine

```
XINPUT_STATE state;
ZeroMemory(&state, sizeof(XINPUT_STATE));
DWORD dwResult = XInputGetState(i, &state);
```

XInput

```
typedef struct XINPUT_STATE {
    DWORD dwPacketNumber;
    XINPUT_GAMEPAD Gamepad;
} XINPUT_STATE
```

```
typedef struct XINPUT_GAMEPAD {
    WORD wButtons;
    BYTE bLeftTrigger;
    BYTE bRightTrigger;
    SHORT sThumbLX;
    SHORT sThumbLY;
    SHORT sThumbRX;
    SHORT sThumbRY;
} XINPUT_GAMEPAD
```

wButtons is a word with byteflags for each button.

Device button	Bitmask
XINPUT_GAMEPAD_DPAD_UP	0x0001
XINPUT_GAMEPAD_DPAD_DOWN	0x0002
XINPUT_GAMEPAD_DPAD_LEFT	0x0004
XINPUT_GAMEPAD_DPAD_RIGHT	0x0008
XINPUT_GAMEPAD_START	0x0010
XINPUT_GAMEPAD_BACK	0x0020
XINPUT_GAMEPAD_LEFT_THUMB	0x0040
XINPUT_GAMEPAD_RIGHT_THUMB	0x0080
XINPUT_GAMEPAD_LEFT_SHOULDER	0x0100
XINPUT_GAMEPAD_RIGHT_SHOULDER	0x0200
XINPUT_GAMEPAD_A	0x1000
XINPUT_GAMEPAD_B	0x2000
XINPUT_GAMEPAD_X	0x4000
XINPUT_GAMEPAD_Y	0x8000

XInput

Check for example if Gamepad button A is pressed:

```
bool IsButtonAPressed(const XINPUT_GAMEPAD& gamepad)
{
  return ((gamepad.wButtons & XINPUT_GAMEPAD_A) != 0);
}
```

Better, somewhere during `process_input()`:

```
CopyMemory(&previousState, &currentState, sizeof(XINPUT_STATE));
ZeroMemory(&currentState, sizeof(XINPUT_STATE));
XInputGetState(m_controllerIndex, &currentState);

auto buttonChanges = currentState.Gamepad.wButtons ^ previousState.Gamepad.wButtons;
buttonsPressedThisFrame = buttonChanges & currentState.Gamepad.wButtons;
buttonsReleasedThisFrame = buttonChanges & (~currentState.Gamepad.wButtons);
```

XInput

Which enables us to implement the following:

```
bool IsDownThisFrame(unsigned int button) const
{
  return buttonsPressedThisFrame & button;
}

bool IsUpThisFrame(unsigned int button) const
{
  return buttonsReleasedThisFrame & button;
}

bool IsPressed(unsigned int button) const
{
  return currentState.Gamepad.wButtons & button;
}
```

XInput

```
CopyMemory(&previousState, &currentState, sizeof(XINPUT_STATE));
ZeroMemory(&currentState, sizeof(XINPUT_STATE));
XInputGetState(m_controllerIndex, &currentState);
```

Which buttons do we check here?

```
(currentState.Gamepad.wButtons & 16) == 16
(currentState.Gamepad.wButtons & 68) == 68
```

Say

`currentState.Gamepad.wButtons` is `0b00010100`

Which of the two return true?

Device button	Bitmask
XINPUT_GAMEPAD_DPAD_UP	0x0001
XINPUT_GAMEPAD_DPAD_DOWN	0x0002
XINPUT_GAMEPAD_DPAD_LEFT	0x0004
XINPUT_GAMEPAD_DPAD_RIGHT	0x0008
XINPUT_GAMEPAD_START	0x0010
XINPUT_GAMEPAD_BACK	0x0020
XINPUT_GAMEPAD_LEFT_THUMB	0x0040
XINPUT_GAMEPAD_RIGHT_THUMB	0x0080
XINPUT_GAMEPAD_LEFT_SHOULDER	0x0100
XINPUT_GAMEPAD_RIGHT_SHOULDER	0x0200
XINPUT_GAMEPAD_A	0x1000
XINPUT_GAMEPAD_B	0x2000
XINPUT_GAMEPAD_X	0x4000
XINPUT_GAMEPAD_Y	0x8000

XInput

```
auto buttonChanges = currentState.Gamepad.wButtons ^ previousState.Gamepad.wButtons;
buttonsPressedThisFrame = buttonChanges & currentState.Gamepad.wButtons;
buttonsReleasedThisFrame = buttonChanges & (~currentState.Gamepad.wButtons);
```

Say

`previousState.Gamepad.wButtons` is `0b00010000`

`currentState.Gamepad.wButtons` is `0b00010100`

What is `buttonChanges`?

What is `buttonsPressedThisFrame`?

What is `buttonsReleasedThisFrame`?

Say

`previousState.Gamepad.wButtons` is `0b00010001` instead

What is `buttonsReleasedThisFrame` now?

Device button	Bitmask
XINPUT_GAMEPAD_DPAD_UP	0x0001
XINPUT_GAMEPAD_DPAD_DOWN	0x0002
XINPUT_GAMEPAD_DPAD_LEFT	0x0004
XINPUT_GAMEPAD_DPAD_RIGHT	0x0008
XINPUT_GAMEPAD_START	0x0010
XINPUT_GAMEPAD_BACK	0x0020
XINPUT_GAMEPAD_LEFT_THUMB	0x0040
XINPUT_GAMEPAD_RIGHT_THUMB	0x0080
XINPUT_GAMEPAD_LEFT_SHOULDER	0x0100
XINPUT_GAMEPAD_RIGHT_SHOULDER	0x0200
XINPUT_GAMEPAD_A	0x1000
XINPUT_GAMEPAD_B	0x2000
XINPUT_GAMEPAD_X	0x4000
XINPUT_GAMEPAD_Y	0x8000

XInput

Why the hassle? So that instead of

```
bool IsDownThisFrame(unsigned int button) const
{
  return ((currentState.Gamepad.wButtons & button) != 0) &&
    ((previousState.Gamepad.wButtons & button) == 0);
}
```

We can now write

```
bool IsDownThisFrame(unsigned int button) const
{
  return buttonsPressedThisFrame & button;
}
```

XInput

```
typedef struct XINPUT_STATE {
    DWORD dwPacketNumber;
    XINPUT_GAMEPAD Gamepad;
} XINPUT_STATE
```

```
typedef struct XINPUT_GAMEPAD {
    WORD wButtons;
    BYTE bLeftTrigger;
    BYTE bRightTrigger;
    SHORT sThumbLX;
    SHORT sThumbLY;
    SHORT sThumbRX;
    SHORT sThumbRY;
} XINPUT_GAMEPAD
```

A byte for the triggers (8-bit unsigned)

- [0 – 255]

A short for the thumbsticks (16bit signed)

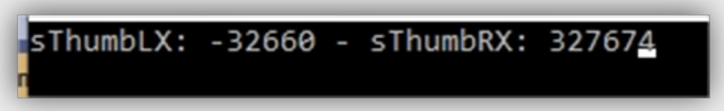
- [-32768 – 32767]

Take deadzones into account!

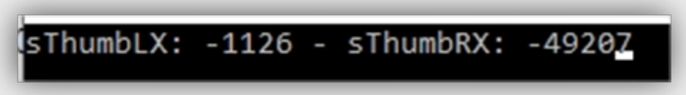
Deadzones you say?

```cpp
#define WIN32_LEAN_AND_MEAN
#include <windows.h>
#include <XInput.h>
#include <iostream>
#include <thread>

#pragma comment(lib, "xinput.lib")

int main()
{
    XINPUT_STATE currentState{};
    int controllerIndex{};

    while (true)
    {
        auto t = std::chrono::high_resolution_clock::now();

        ZeroMemory(&currentState, sizeof(XINPUT_STATE));
        XInputGetState(controllerIndex, &currentState);

        std::cout << "\rsThumbLX: " << currentState.Gamepad.sThumbLX
          << " - sThumbRX: " << currentState.Gamepad.sThumbRX;

        if (currentState.Gamepad.wButtons & XINPUT_GAMEPAD_B)
            break;

        auto t2 = std::chrono::high_resolution_clock::now() - t;
        t += std::chrono::milliseconds(16) - t2; // we want ~60 fps
        std::this_thread::sleep_until(t);
    }
}
```

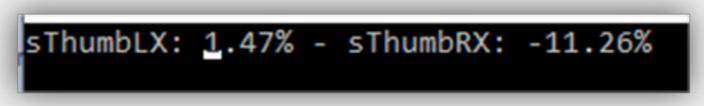
With both thumbs in opposite directions:



Released again:



In percentages:



Input via interrupts

Interrupts – IRQ

- When state of a device changes (p.ex. a mouse has moved) an interrupt request signal is sent to the CPU
- Main program is halted shortly, input data is processed (ISR), main continues and can work with the received data.
- When we process input, we process the received interrupts since the last frame one by one

```
// Main message loop:
while (GetMessage(&msg, nullptr, 0, 0)) {
    if (!TranslateAccelerator(msg.hwnd, hAccelTable, &msg)) {
        TranslateMessage(&msg);
        DispatchMessage(&msg);
    }
}
```

Input via interrupts

Interrupts – IRQ

- When state of a device changes (p.ex. a mouse has moved) an interrupt request signal is sent to the CPU
- Main program is halted shortly, input data is processed (ISR), main continues and can work with the received data.
- When we process input, we process the received interrupts since the last frame one by one

```
bool dae::InputManager::ProcessInput() {
  SDL_Event e;
  while (SDL_PollEvent(&e)) {
    if (e.type == SDL_QUIT) {
      return false;
    } else if (e.type == SDL_KEYDOWN) {

    } elseif (e.type == SDL_MOUSEBUTTONDOWN) {

    }
    // etc...
  }
  return true;
}
```

Input

Wireless input devices

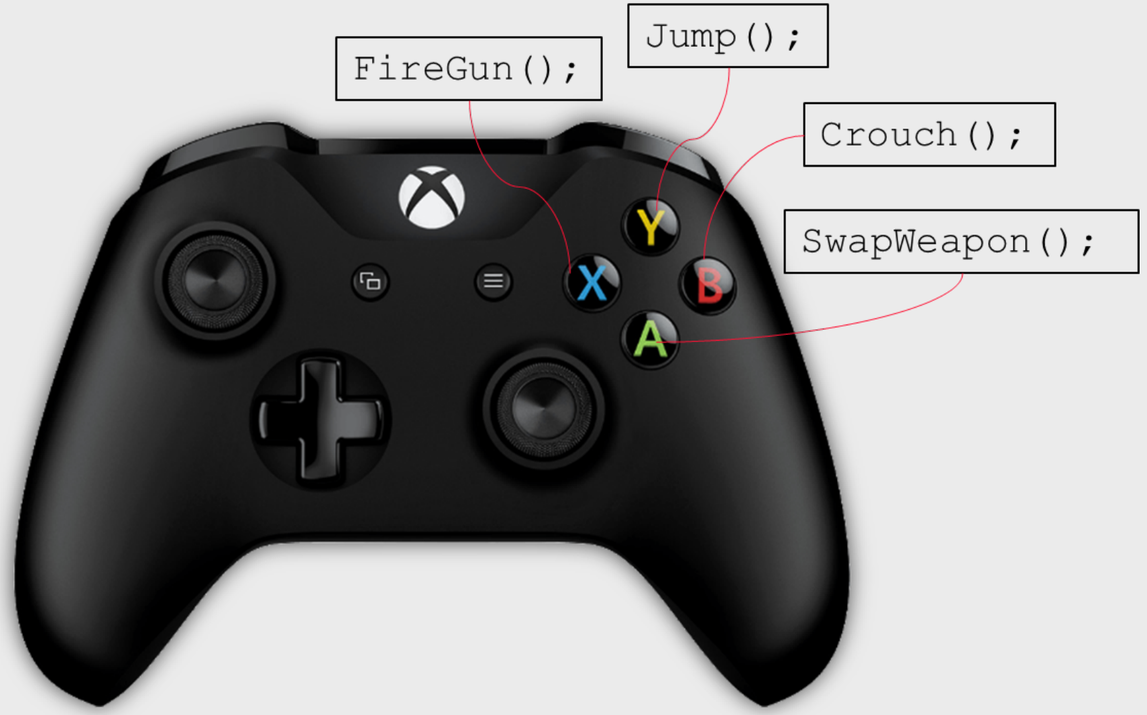
- Often via Bluetooth
- Need a separate thread to receive the data send by the device over the network
- And to send data back to the device (like sound and rumble data)
- Often abstracted away behind an API Layer.

Problem statement

```
if(is_pressed(BUTTON_Y))
  Jump();
else if (is_pressed(BUTTON_X))
  Firegun();
else if (is_pressed(BUTTON_A))
  SwapWeapon();
else if (is_pressed(BUTTON_B))
  Crouch();
```

What's wrong with this code?

How can we improve it?



Command

```
class Command
{
  public:
   virtual ~Command() = default;
   virtual void Execute() = 0;
}

class Jump : public Command
{
  public:
    void Execute() override { Jump(); }
}

class Fire : public Command
{
  public:
    void Execute() override { Fire(); }
}
```

Command

Even better:

```
class GameActorCommand : public Command
{
  GameActor* m_actor;
protected:
  GameActor* GetGameActor() const { return m_actor; }
public:
  GameActorCommand(GameActor* actor);
  virtual ~GameActorCommand();
}

class Fire : public GameActorCommand {
public:
  void Execute() override
  {
    GetGameActor()->Fire();

    // additional code is possible too, of course
  }
}
```

Command

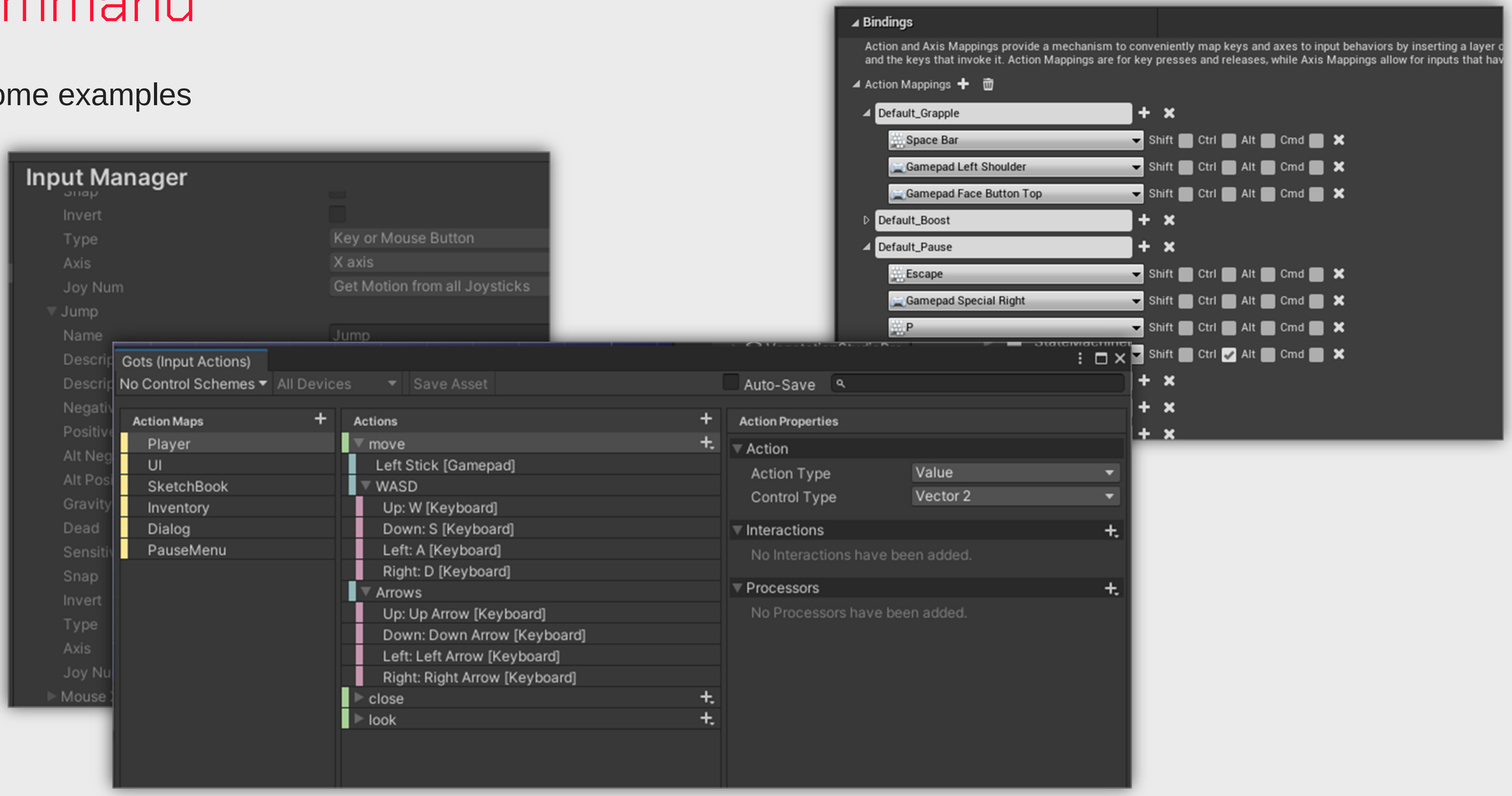
These commands need to be registered with the Input manager

- The input manager keeps track of all active commands
- Checks if the input for the command has been executed by the user
- Calls the Execute method on the registered command
- Don't forget to unregister!

Mapping the input to the commands is up to you.

Command

Some examples



Command

Editors often (always?) work with stacked commands, to enable Undo/Redo functionality.

```
class EditorCommand : public Command
{
  public:
   virtual ~EditorCommand() = default;
   virtual void Undo() = 0;
}
```

This is how virtually all commands in software works... Of course, in-game actions don't often need an Undo, so make a distinction!

Pimpl

Is a C++ pattern/idiom

> Remove compilation dependencies on internal class implementations and improve compile times

Item #43 from C++ Coding Standards by Herb Sutter: “Pimpl judiciously”

Advantages

- Faster compilation times
  - (easier project setup too)
- Avoids ambiguity

Example

The Renderer - we want to dynamically choose between DirectX and OpenGL - do you see the problem?

Renderer.h:

```
class Renderer abstract
{
public:
    virtual void RenderTriangles(
      float* verts, int* indices) = 0;
};
```

OpenGLRenderer.h:

```
#include "Renderer.h"
#include <SDL.h>

class OpenGLRenderer : public Renderer
{
public:
    void RenderTriangles(
      float* verts, int* indices) override;
private:
    SDL_Texture* m_pRenderTexture;
};
```

DirectXRenderer.h:

```
#include "Renderer.h"
#include <d3d11.h>

class DirectXRenderer : public Renderer
{
public:
    void RenderTriangles(
      float* verts, int* indices) override;
private:
    ID3D11Texture2D* m_pRenderTexture;
};
```

Example

Let's apply Pimpl.

OpenGLRenderer.h:

```
#include "Renderer.h"

class OpenGLRenderer : public Renderer
{
    class OpenGLRendererImpl;
    OpenGLRendererImpl* m_pImpl;
public:
    void RenderTriangles(
      float* verts, int* indices) override;
};
```

OpenGLRenderer.cpp:

```
#include "OpenGLRenderer.h"
#include <SDL.h>

class OpenGLRenderer::OpenGLRendererImpl
{
    SDL_Texture* m_pRenderTexture;
  public:
    void DoRenderTriangles(
      float* verts, int* indices);
};

void OpenGLRenderer::OpenGLRendererImpl::
  DoRenderTriangles(float* verts, int* indices) {
    // the actual implementation
  }

void OpenGLRenderer::RenderTriangles(
  float* verts, int* indices) {
    m_pImpl->DoRenderTriangles(verts, indices);
}
```