

Command & Pimpl



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
 - o XInputGetState()

```
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	8000x0
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	8000x0
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	Device button	Bitmask
previousState.Gamepad.wButtons is 0b00010000	XINPUT_GAMEPAD_DPAD_UP	0x0001
currentState.Gamepad.wButtons is 0b00010100	XINPUT_GAMEPAD_DPAD_DOWN XINPUT_GAMEPAD_DPAD_LEFT	0x0002 0x0004
What is buttonChanges ?	XINPUT_GAMEPAD_DPAD_RIGHT	8000x0
What is buttonsPressedThisFrame ?	XINPUT_GAMEPAD_START	0x0010
What is buttonsReleasedThisFrame?	XINPUT_GAMEPAD_BACK	0x0020
	XINPUT_GAMEPAD_LEFT_THUMB	0x0040
Say	XINPUT_GAMEPAD_RIGHT_THUMB	0x0080
previousState.Gamepad.wButtons is 0b00010001	XINPUT_GAMEPAD_LEFT_SHOULDER	0x0100
instead	XINPUT_GAMEPAD_RIGHT_SHOULDER	0x0200
ITIOCOCC	XINPUT_GAMEPAD_A	0x1000
What is buttonsReleasedThisFrame now?	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;
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    SHORT sThumbLX;
    SHORT sThumbLY;
    SHORT sThumbRY;
    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?

Programming 4

```
#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</pre>
          << " - 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:

SThumbLX: -32660 - sThumbRX: 327674

Released again:

SThumbLX: -1126 - sThumbRX: -49207

In percentages:

SThumbLX: 1.47% - sThumbRX: -11.26%
```

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
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```
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

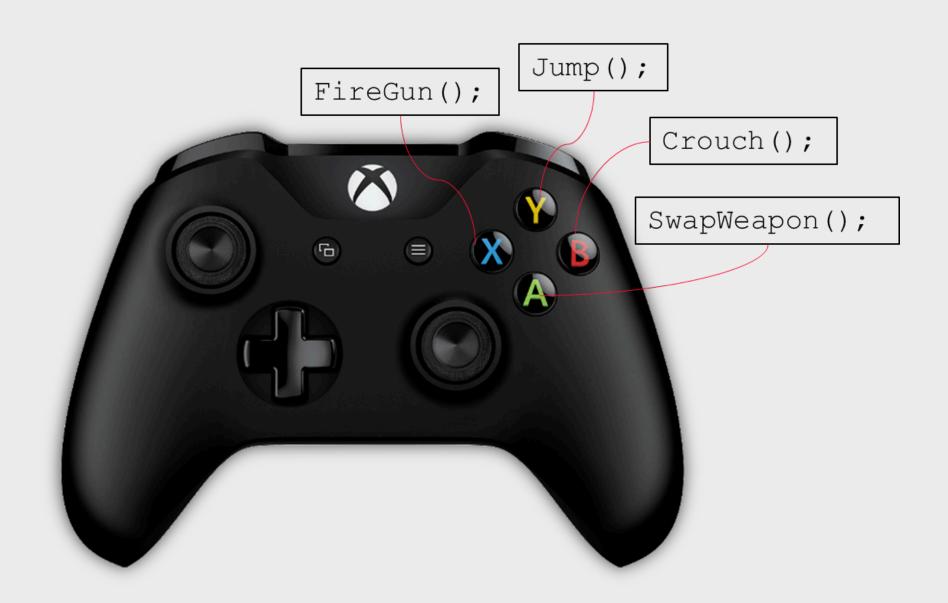
- Often via Bluetooth
- Need a separate thread to receive the data send by the device over the network
- And to send data back to the device (like sound and rumble data)
- Often abstracted away behind an API Layer.

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
```

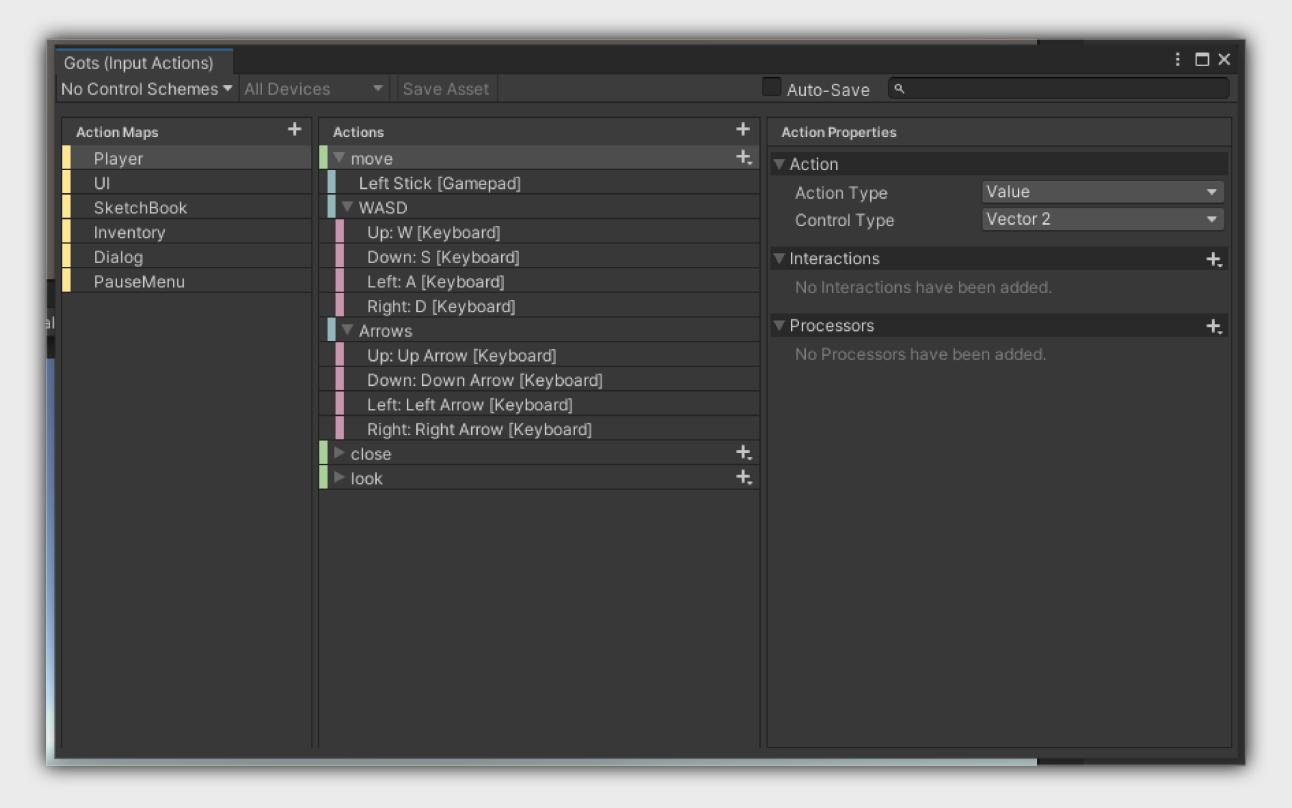
Command

These commands need to be registered with the Input manager

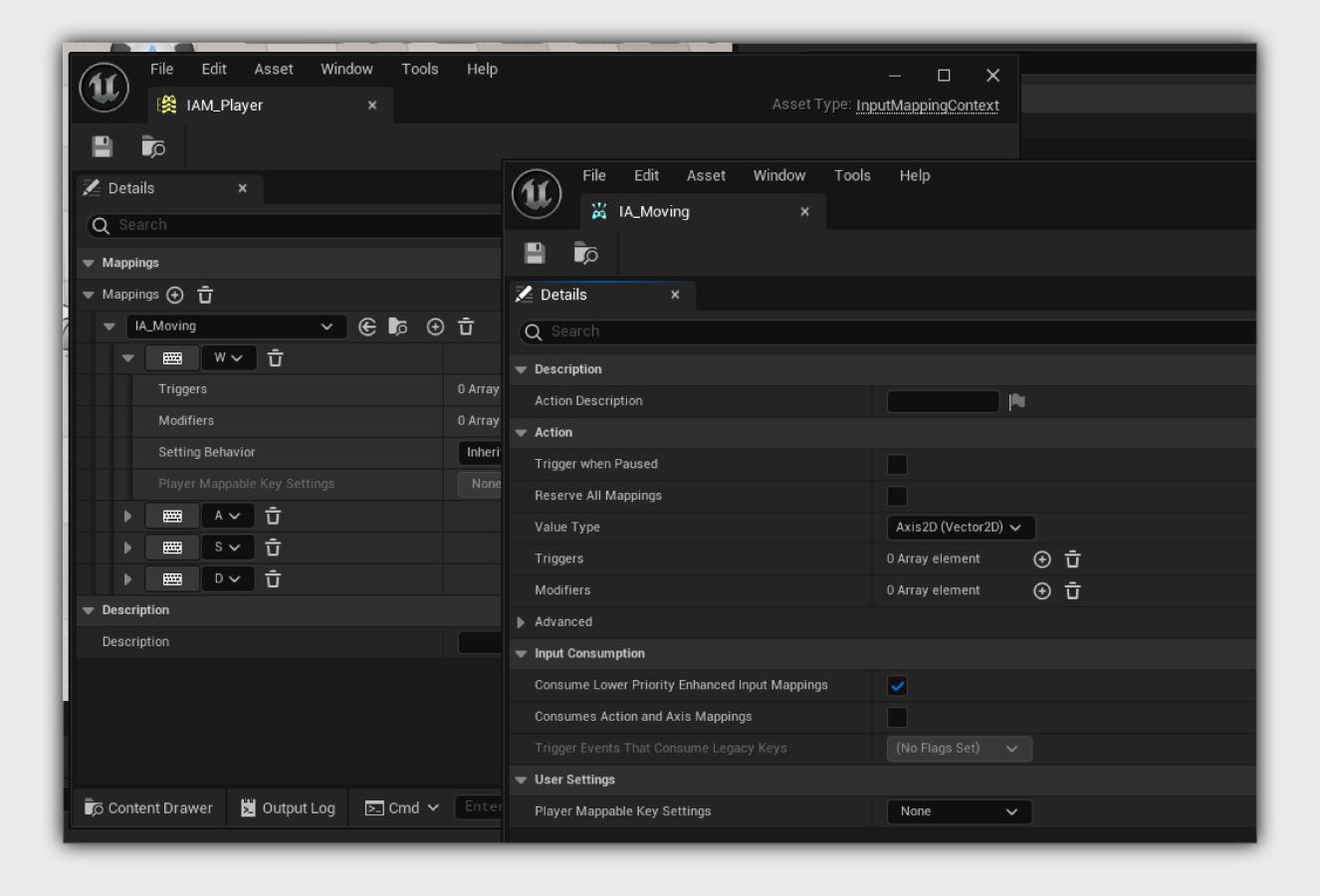
- The input manager keeps track of all active commands
- Checks if the input for the command has been executed by the user
- Calls the Execute method on the registered command
- Don't forget to unregister!

Mapping the input to the commands is up to you.

Actions in Unity



Actions in Unreal



Actions

Actions is the mapping of some input to an ID. This id then gets mapped to a certain command or function.

```
if (auto EnhancedInputComponent = Cast<UEnhancedInputComponent>(InputComponent))
{
   EnhancedInputComponent->BindAction(MoveAction, ETriggerEvent::Triggered, this,
   &AMyPlayerController::OnMove);
}
```

Command

Editors (not games) 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!

Success & Failure

The command pattern allows to have command "state"

- Success the command was executed successfully
- Failed the command returned an error
- Canceled the command is not executed for some reason
- It can keep track of how many times it has been executed

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

https://cpppatterns.com/patterns/pimpl.html

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);
```