Game Control
Game Programming

- Rendering
- Looping and control
- Math
- Behaviour and navigation (AI)
- Physics
- Animation and effects
- Networking
Game Programming

- Rendering
- Looping and control
- Math
- Behaviour and navigation (AI)
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https://en.wikipedia.org/wiki/Game_controller
https://en.wikipedia.org/wiki/Game_controller
Analog

https://en.wikipedia.org/wiki/Game_controller
Analog² + Digital⁶

https://en.wikipedia.org/wiki/Game_controller
Float² \times \text{X} \rightarrow \text{Bool}

https://en.wikipedia.org/wiki/iPhone
Value

ValueChanged

Float

Bool
State

Float

Event

State

Bool
Float

Bool
Float

Bool
State

Float

to

Bool

game time

question mark

Float

game time
Value thresholding

State

Float

game time

to

Bool

game time
Value thresholding

State $\rightarrow$ State

Float

Bool
Float to Bool

State
Gradient thresholding → State $\rightarrow$ Event

Float to Boolean

game time

¿?
Gradient thresholding

State $\rightarrow$ Event

Float

to

Bool
Gradient thresholding

State → Event → State

Float

to

Bool
State

Bool to Float

game time

?
State → Event

Bool
to

Float
State → Event → State

Bool

to

Float

game time

game time
State → Event → State

game time

to

Bool

Float
Raw inputs

X-Axis,
Button A,
Button B
Raw inputs

Semantic / Interpreted inputs

X-Axis,
Button A,
Button B

MoveHorizontal
Attack
Jump
Raw inputs

Semantic / Interpreted inputs

Game code

X-Axis,
Button A,
Button B

MoveHorizontal
Attack
Jump

GetState("MoveHorizontal"),
OnEvent("Attack")
OnEvent("Jump")
Event State

Event State

game time
## UnityEngine.Input

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
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<tbody>
<tr>
<td>GetAxis</td>
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<tr>
<td>GetButton</td>
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<td>Returns true the first frame the user releases the virtual button identified by buttonName.</td>
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</tr>
<tr>
<td>GetKey</td>
<td>Returns true while the user holds down the key identified by name.</td>
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<td>GetMouseButton</td>
<td>Returns whether the user is pressing the given mouse button.</td>
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<td>GetMouseButtonDown</td>
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Event triggered in FixedUpdate() or Update()?
### UnityEngine.Input

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**Event triggered in Update()**
Input System Package (in Dev)

Input System Package

Update Mode
Process Events In Dynamic Update

Timeslice Events
Filter Noise On Current
Compensate For Screen

Default Deadzone Min: 0.125
Default Deadzone Max: 0.925
Default Button Press Point: 0.5
Default Tap Time: 0.2
Default Slow Tap Time: 0.5
Default Hold Time: 0.4
Tap Radius: 5
Multi Tap Delay Time: 0.75
Game code

Semantic / Interpreted inputs

Raw inputs

X-Axis,
Button A,
Button B

MoveHorizontal
Attack
Jump

GetState("MoveHorizontal"),
OnEvent("Attack")
OnEvent("Jump")
Project Settings > InputManager (Legacy)
State Event

State

Event

State Event

UP

DOWN

UP

DOWN
State 0  State 1

game time
State 0 \quad \xrightarrow{\text{OnState1Enter}} \quad \text{State 1}
State 0

OnState0Enter

OnState0Exit

State1

OnState1Enter

State0to1

game time
How many button states?
How many button states?

- Normal
- Pressed
How many button states?

- Normal
- Pressed
- onMouseDown
- onMouseEnter
- onMouseOver
How many button states?

Normal

Pressed

onMouseDown
onMouseUp
onMouseEnter
onMouseOver
How many button states?

- Normal
- Pressed
- Highlighted

Events:
- onMouseDown
- onMouseUp
- onMouseEnter
- onMouseExit
- onMouseDrag
- onMouseOver
How many button states?

**BUTTON**

- Normal
- Pressed
- Highlighted
- Disabled

- onMouseDown
- onMouseUp
- onMouseEnter
- onMouseExit
- onMouseDrag
- onMouseOver
How many button states?

Normal
Pressed
Highlighted
Disabled
Clicked?
How many button states?

- Normal
- Pressed
- Highlighted
- Disabled
- Clicked?

- `onMouseDown`
- `onMouseUp`
- `onMouseUpAsButton`
- `onMouseEnter`
- `onMouseExit`
- `onMouseDrag`
- `onMouseOver`
How many button states?

- Normal
- Pressed
- Highlighted
- Disabled
- Clicked?
How many button states?

- Normal
- Pressed
- Highlighted
- Disabled
- Clicked?

Events:
- `onMouseDown`
- `onMouseUp`
- `onMouseUpAsButton`
- `onMouseEnter`
- `onMouseExit`
- `onMouseDrag`
- `onMouseOver`
Finite-state machine
Finite-state machine

- Normal
- Highlighted
- Pressed
- Disabled

Transitions:
- onMouseEnter
- onMouseExit
- onMouseDown
- onMouseUp

States:
- Normal
- Highlighted
- Pressed
- Disabled
Finite-state machine

[Diagram showing states and transitions: Normal, Highlighted, Pressed, and Disabled, with events onMouseEnter, onMouseDown, onMouseExit, and onMouseUp. Question mark for Order of events?]

3D Game Kit
Animator Controller

Entry

Respawn

BeginRespawn

EllenDeath

AirborneSM

IdleSM

MeleeCombatSM

LocomotionSM

LandingSM

Any State

Hurt
Animator Parameters
Animator Parameters

[Diagram showing various parameters and states for a character animation system]
Animator Parameters

- FootFall: 0.0
- VerticalSpeed: 0.0
- AirborneVerticalSpeed: 0.0
- ForwardSpeed: 0.0
- AngleDeltaRad: 0.0
- RandomIdle: 0
- TimeoutToldle
- Grounded
- InputDetected
- MeleeAttack
- Hurt
- Death
- Respawn
Animator Parameters

- FootFall
- VerticalSpeed
- AirborneVerticalSpeed
- ForwardSpeed
- AngleDeltaRad
- RandomIdle
- TimeoutOldIdle
- Grounded
- InputDetected
- MeleeAttack
- Hurt
- Death
- Respawn

Trigger

Base Layer

Entry

BeginRespawn

AirborneSM

IdleSM
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SetBool</td>
<td>Sets the value of the given boolean parameter.</td>
</tr>
<tr>
<td>SetFloat</td>
<td>Send float values to the Animator to affect transitions.</td>
</tr>
<tr>
<td>SetInteger</td>
<td>Sets the value of the given integer parameter.</td>
</tr>
<tr>
<td>SetTrigger</td>
<td>Sets the value of the given trigger parameter.</td>
</tr>
</tbody>
</table>
Control the animator with your custom script
Control the animator with your custom script

Your custom script

Animator
Control the animator with your custom script

Your custom script

Update animator parameters

Animator
Animation event

FBX Importer Settings (Inspector) (.fbx)
Animation event

FBX Importer Settings (Inspector) (.fbx)

AnimationClip (Animation Window) (.anim)
Send animation events to custom script

Your custom script

Send events to custom script

Update animator parameters

Animator
StateMachineBehaviour

Entry

Respawn

BeginRespawn

ElienDeath

AirborneSM

IdleSM

MeleeCombatSM

LocomotionSM

LandingSM

Any State

Hurt
StateMachineBehaviour

Entry → Respawn → BeginRespawn → EllenDeath

AirborneSM, IdleSM, MeleeCombatSM, LocomotionSM

Transitions:
- BeginRespawn → Respawn

Inspector:
- Motion: None (Motion)
- Speed: 0
- Multiplier: Parameter
- Motion Time: Parameter
- Mirror: Parameter
- Cycle Offset: 0
- Foot IK: Parameter
- Write Defaults

Effects:
- (Ellen Respawn Effect)
- Script: EllenRespawnEffect

Add Behaviour
public class EllenRespawnEffect : StateMachineBehaviour
{
    public override void OnStateEnter(
        Animator animator,
        AnimatorStateInfo stateInfo,
        int layerIndex)
    {
        animator.GetComponent<PlayerController>().Respawn();
    }
}
Animator Override Controller
Finite-state machine

Order of events?
State as triggered event

- Normal
- Highlighted
- Pressed
- Disabled

Transitions:
- isEnabled
- !isEnabled
- isMouseOutside
- !isMouseOutside
- isMousePressed
- !isMousePressed
State as triggered event

![Diagram of button states and transitions]

- Normal
- Highlighted
- Pressed
- Disabled

Transitions:
- `!isMouseOutside` from Normal to Highlighted
- `isMousePressed` from Highlighted to Pressed
- `isEnabled` from Disabled to Normal
- `!isEnabled` from Normal to Disabled
- `!isMouseOutside` from Highlighted to Normal
- `!isMousePressed` from Pressed to Highlighted
- Button position transitions:
  - Outside to Inside
  - Inside to Outside
  - Normal to Pressed
  - Pressed to Normal
Clicked?

Diagram:

- Normal
- Highlighted
- Pressed
- Disabled

Edges:
- isEnabled
- !isEnabled
- isMouseOutside
- !isMouseOutside
- isMousePressed
- !isMousePressed
Clicked?

![Diagram of state transitions involving isMousePressed, !isMousePressed, isEnabled, !isEnabled, isMouseOutside, and !isMouseOutside.](image)

(send a clicked event?)
Clicked?

Diagram showing transitions between states:
- Normal
- Highlighted
- Pressed
- Disabled

Transitions:
- !isMousePressed && isMouseOutside
- isMousePressed
- !isMouseOutside
- !isEnabled
- isMouseOutside
- !isEnabled
- !isMousePressed && !isMouseOutside

States:
- Normal
- Highlighted
- Pressed
- Disabled

Enabled/Disabled:
- isEnabled
- !isEnabled

Additional note:
(wait one frame / send a clicked event)
isEnabled = false?

Diagram:

- **Normal**
  - isEnabled
  - !isEnabled
  - isMouseOutside
  - !isMousePressed & isMouseOutside

- **Highlighted**
  - isMouseOutside
  - !isMousePressed & isMouseOutside

- **Pressed**
  - isMousePressed
  - !isMousePressed & !isMouseOutside

- **Disabled**
  - isEnabled
  - !isEnabled

(wait one frame / send a clicked event)
isEnabled = false?

Diagram:

- Normal
- Highlighted
- Pressed
- Diabled
- Clicked

Transitions:

- !isMousePressed && isMouseOutside
- !isMouseOutside
- isMousePressed
- isEnabled
- !isEnabled
- !isMouseOutside
- !isMousePressed && !isMouseOutside

Conditions:

- (wait one frame / send a clicked event)
IsEnabled = false?

AnyState

<table>
<thead>
<tr>
<th>AnyState</th>
<th>Diabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>!isEnabled</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Normal</th>
<th>Highlighted</th>
<th>Pressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>!isMousePressed &amp;&amp; isMouseOutside</td>
<td>!isMouseOutside</td>
<td>!isMousePressed &amp;&amp; !isMouseOutside</td>
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</table>

<p>| | |</p>
<table>
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<tr>
<th></th>
<th></th>
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<tbody>
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<td>.isEnabled</td>
<td>isMouseOutside</td>
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(wait one frame / send a clicked event)
Sub-state machines
Hierarchical state machine
Pushdown automata
Concurrent state machines

Game

Ellen
- Idle
- Locomotion

Enemy

Door

UI

Stack
Game state tree / store

Singleton pattern, Global variables, ...

Scenes, DontDestroyOnLoad,

GameObjects in a hierarchy

Animators

Game

Ellen

Idle

Locomotion

Enemy

Door

UI

Stack
Save / Load?

Singleton pattern,
Global variables, ...

Scenes,
DontDestroyOnLoad,

GameObjects
in a hierarchy

Animators

Game

Ellen

Enemy

Door

UI

Idle

Locomotion

Stack
Game

Ellen

Idle

Locomotion

Enemy

UI

Hierarchy

Level1

----- System -----
SceneController
TransitionStart
TransitionDestination
Level01PostProcessVolumes
Level01Music
Level01Audio
Level01ReverbZones
GlobalShaderSettings
----- UI -----
ScreenFader
MenuCanvases
HealthCanvas
Level01InformationZones
----- PlayerAssets -----
CameraRig

Enemies

----- Gameplay -----
Level01Gameplay
Destructibles
DeathVolume
Level01Sequences
----- LevelAssets -----
Skybox
Environment
Effects
Water
----- Lighting -----
Lights
ShadowBlockers
LightProbes
ReflectionProbes
----- SpawnedPrefabs -----
How to “Pause” a game?
MonoBehaviour.Update() / FixedUpdate()

- Hold the local state
  - enum State { Normal, Pressed, Highlighted, Disabled, Clicked };
    - with other data members
- Update the local state in Update() / FixedUpdate() or Coroutine with a hierarchical approach.
  - only read other objects' states if possible.
  - only receive / send "state events" if unavoidable
- Apply If-else chain, switch or state pattern
Script Execution Order settings

Script Execution Order

Add scripts to the custom order and drag them to reorder.

Scripts in the custom order can execute before or after the default time and are executed from top to bottom. All other scripts execute at the default time in the order they are loaded.

(Changing the order of a script may modify the meta data for more than one script.)

<table>
<thead>
<tr>
<th>Default Time</th>
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</tr>
</thead>
<tbody>
<tr>
<td>UnityEngine.EventSystems.HoloLensInput</td>
<td>100</td>
</tr>
<tr>
<td>LoadBundle</td>
<td>200</td>
</tr>
<tr>
<td>UnityEngine.XR.WSA.SpatialMappingBase</td>
<td>250</td>
</tr>
<tr>
<td>LoadTextures</td>
<td>300</td>
</tr>
<tr>
<td>BuildiOSAppSlices</td>
<td>400</td>
</tr>
</tbody>
</table>

Revert  Apply