CS354P

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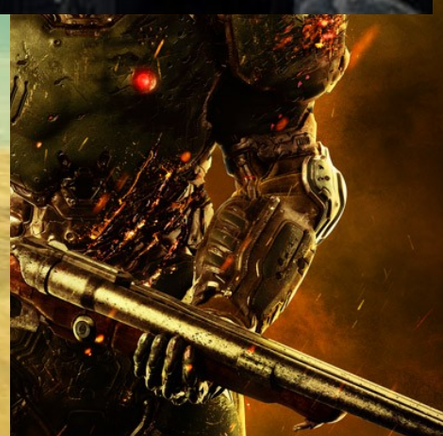
OVERVIEW: PLAYER PACKAGE

MANY GAMES HAVE PLAYABLE CHARACTERS

- Playable characters can:
  - Build story and narrative
  - Provide a direct emotional hook for players
  - Provide a blank template for role-playing/power fantasy
- Regardless of intended experience:
  - Player spends the most time looking at them
  - Player interacts with the world through them



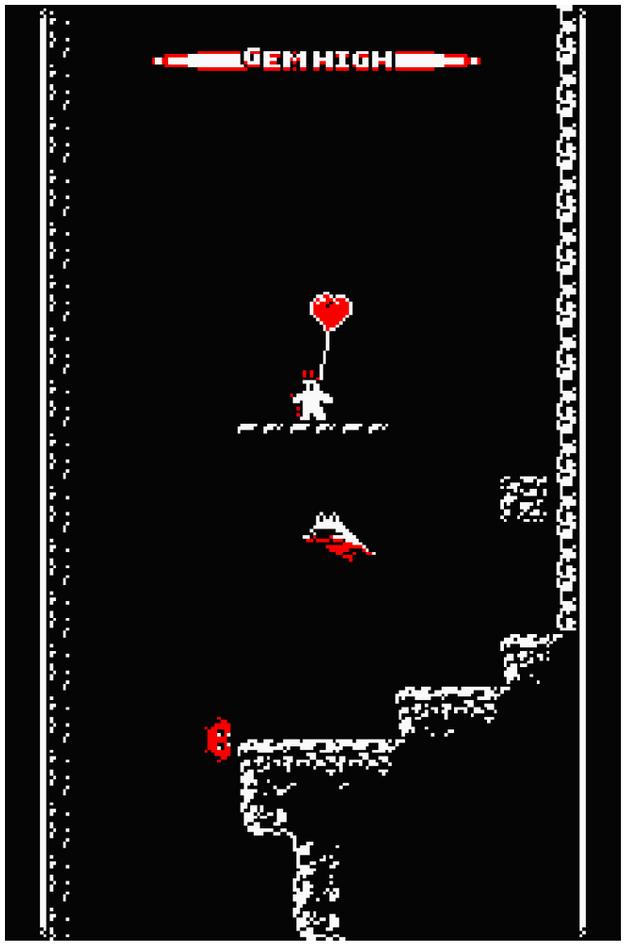
PLAYER PACKAGE

- General term for player character's abilities and movements
- Directly tied to character animations and the responsiveness of the controls
- Coordinated effort by designers, programmers, and artists to create an enjoyable* way to interact with the game

*Or not...

CHARACTER MOVEMENTS

- Way in which a player moves the character through the world
  - Walking
  - Jumping
  - Flying
  - Swimming
  - Crawling
  - etc..
- Usually physically based
  - Simulated or kinematic
- Usually separate from “abilities” but not necessarily…



Downwell

SIMULATED

- Object in the scene is subject to physics
  - Applied forces change its velocity
  - Interactions with other simulated objects affect it

QWOP

KINEMATIC

- Object in the scene is subject to movements and trajectories *outside* of physics
  - Not necessarily subject to forces in the simulation
- Affects simulated objects but not necessarily affected by them

Assassin's Creed

SIMULATED OR KINEMATIC?

- Kinematic generally more common as baseline in player packages
  - Can still apply friction, air control etc
  - Reduces wild physics bugs
  - More designer control
- Kinematic objects can still be subject to physical forces
  - Usually handled via callbacks
- Can combine for a hybrid solution

UE5: CHARACTER MOVEMENT COMPONENT

- An Actor component that provides both movement functionality and *network replication* for movements
  - By default attached to Character Actors (a subclass of Pawns designed for bipedal playable characters)
- `PerformMovement` called during Tick to determine desired acceleration based on player input and settings
  - Once finalized calculations are made, movement is applied to the Character
  - Movements sent to the server and applied authoritatively

CHARACTER MOVEMENT MODES

- Enum MovementMode provided to cover basic use-cases of character movement
  - **Walking** applies friction and allows “stepping up” but does not have vertical velocity
  - **Falling** applies gravity after stepping off an edge or jumping
  - **Flying** ignores the effects of gravity
  - **Swimming** applies gravity and buoyancy
  - **Custom** allows creation of custom functionality

CHARACTER MOVEMENT PROPERTIES

- Many, many parameters available for tuning movement
  - Basic physics concerns (mass, maximum acceleration, linear friction, gravity, etc)
  - Game-specific concerns (air control, ledge falling, client-server information, etc)
- If you have a question (how high can I jump, what is my max speed, have I landed, etc) there is probably a property that has an answer
- Helps to know some physics and networking terminology

CHARACTER MOVEMENT FUNCTIONS

- Multiple stages utilized for calculating the character's movement
- Common functions to interact with `CharacterMovementComponent` within the `Character/Pawn` class are:
  - `AddMovementInput`
  - `Jump`
  - `LaunchCharacter`
  - `Crouch/UnCrouch`
- Common ways `CharacterMovementComponent` starts to process these are:
  - `AddForce/AddImpulse`
  - `Crouch/UnCrouch`
  - `Launch`

AN EXAMPLE: LAUNCHCHARACTER (CALLED FROM CHARACTER)

CharacterMovementComponent

```
if (CharacterMovement) {
  FVector FinalVel = LaunchVelocity;
  const FVector Velocity = GetVelocity();

  if (!bXYOverride) {
    FinalVel.X += Velocity.X;
    FinalVel.Y += Velocity.Y;
  }
  if (!bZOverride) {
    FinalVel.Z += Velocity.Z;
  }

  CharacterMovement->Launch(FinalVel);
  OnLaunched(LaunchVelocity, bXYOverride, bZOverride);
}
```

AN EXAMPLE: LAUNCHCHARACTER (HANDLED IN MOVEMENT)

```
void UCharacterMovementComponent::Launch(FVector const& LaunchVel) {
  if ((MovementMode != MOVE_None) && IsActive() && HasValidData()) {
    PendingLaunchVelocity = LaunchVel;
  }
}
bool UCharacterMovementComponent:HandlePendingLaunch() {
  if (!PendingLaunchVelocity.IsZero() && HasValidData()) {
    Velocity = PendingLaunchVelocity;
    SetMovementMode(MOVE_Falling);
    PendingLaunchVelocity = FVector::ZeroVector;
    bForceNextFloorCheck = true;
    return true;
   }
return false;
}
```

Called from `PerformMovement` and `SimulateMovement`

CHARACTER INTERACTIONS

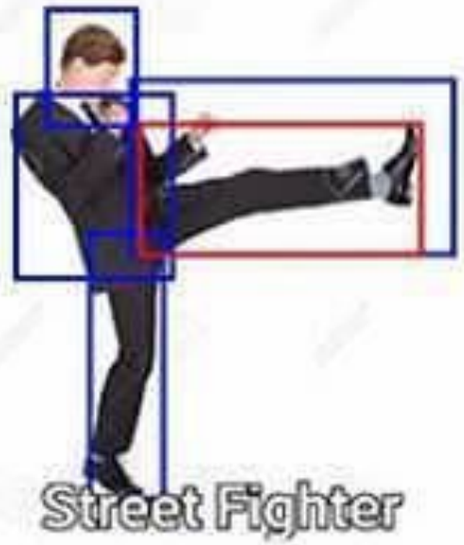
- Way in which the playable character interacts with the world and other playable and non-playable characters
  - Fighting
  - Building
  - Puzzle-solving
  - Talking
  - etc...

Bayonetta 2

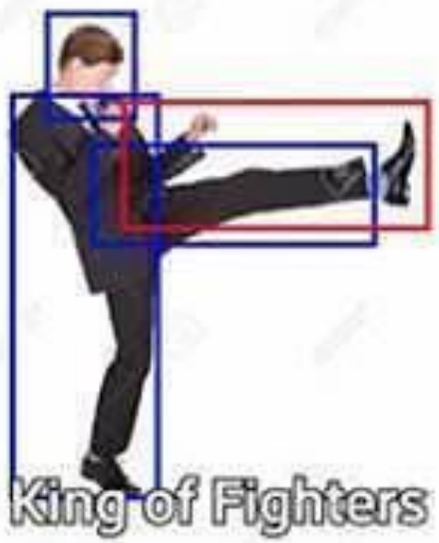
- Implementation depends heavily on the game

HIT AND HURT BOXES

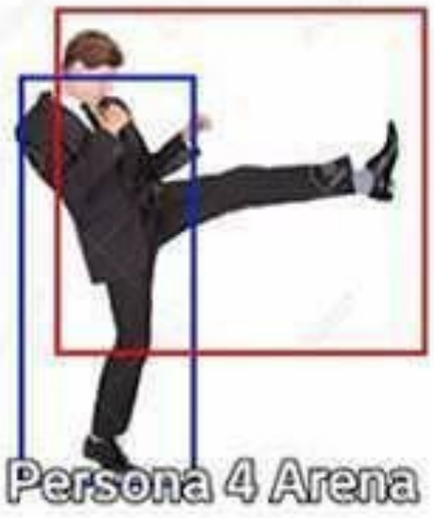
- Primarily terms in fighting games, but used in any game where player characters can deal or receive damage
  - Can more generally be called collision volumes
- Hit boxes provide event information for when the player character has hit something
- Hurt boxes provide event information for when the player character has been hit by something



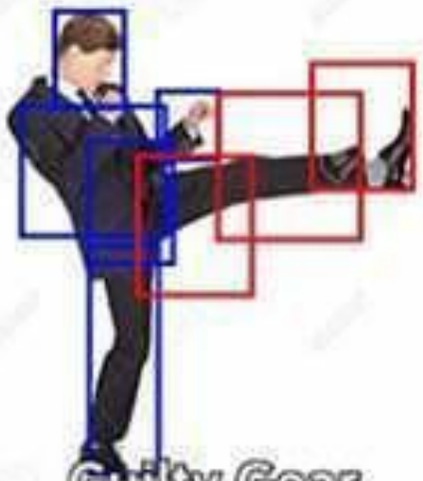
Street Fighter



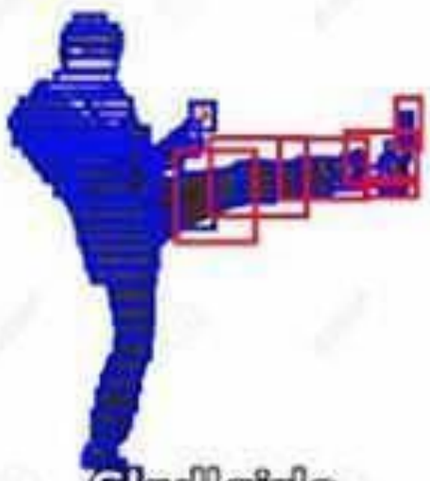
King of Fighters



Persona 4 Arena



Guilty Gear

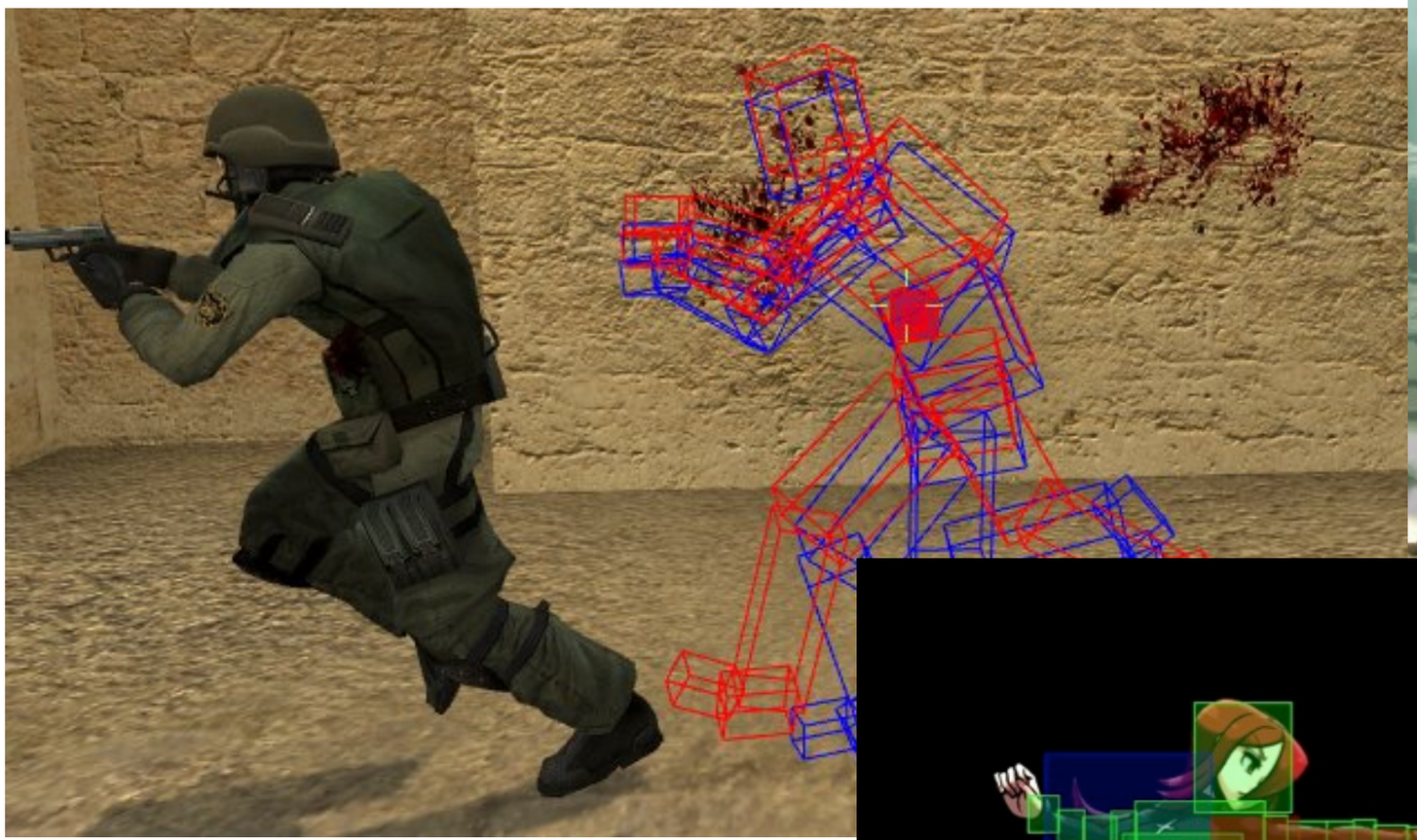


Skullgirls

MONSTER HUNTER

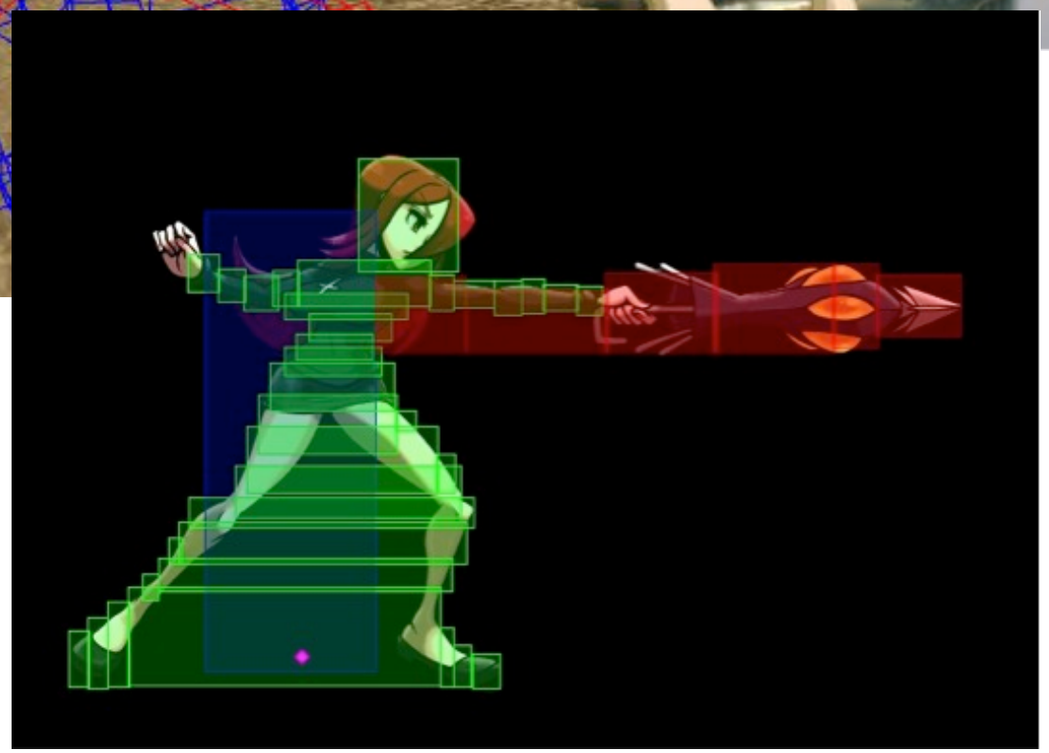
DARK SOULS

NOT STRICTLY WRONG...



Lag compensation in Counter Strike

Guilty Gear

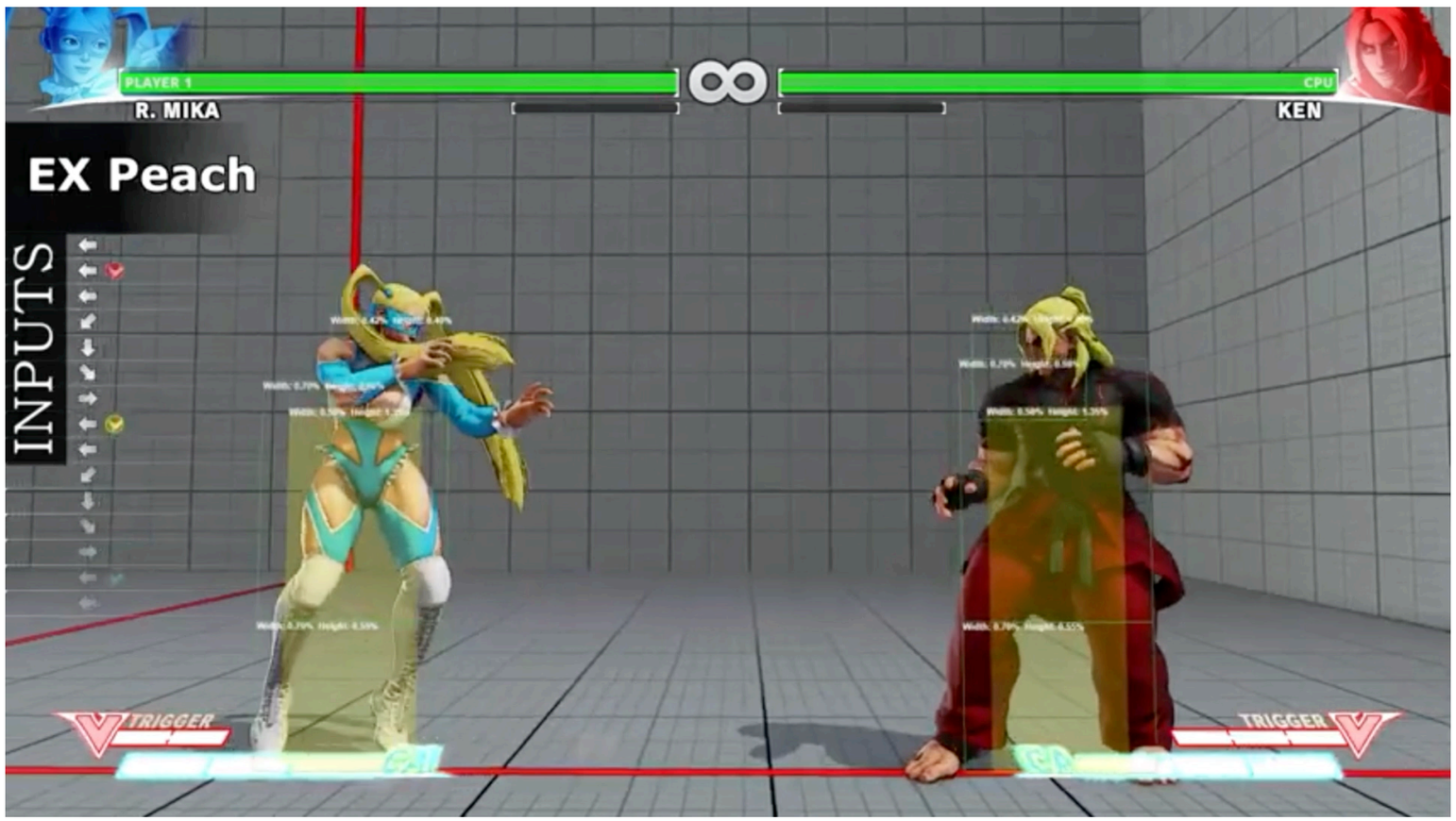


Skullgirls

*the first fighting game “combo” system was a bug in Street Fighter II

IMPLEMENTATION AND DESIGN

- The combinations of hit and hurt (plus additional things like block proximity) boxes leads to a lot of potential states in fighting games
  - Concepts like fuzzy guard/option selects/etc come from these edge cases*



https://www.youtube.com/watch?v=jdGO2rfeKrQ

PICKUPS AND DROPS

- Ability to equip and unequip items or weapons
  - May or may not involve an inventory
- Item is a separate actor
  - Memory management separate from player character
  - Location and orientation matches player character

Spec Ops: The Line

ATTACHING AND DETACHING OBJECTS IN UNREAL

- Two ways to attach an actor to another actor:
  - `AttachToActor`
    - Attaches to root component of Actor
  - `AttachActorToComponent`
    - Attaches to specified component of Actor
- Both functions will work in most situations and both can specify a named socket (e.g. attach an item to a character's hand etc) to attach to
- `FAttachmentTransformRules` specifies how the attached Actor should move relative to the parent Actor

UNREAL: OBJECT SPAWNING

- Can spawn Actors using `UWorld::SpawnActor()`
  - Creates a new instance of specified class
  - Returns pointer to that object
    - Specifies initial position and orientation of spawned Actor
- Can spawn Blueprint Actors by accessing the BP (either via a editor or a reference path) then call SpawnActor as usual:

```
GetWorld()->SpawnActor<MyActor>(MyActorBP,
FVector::ZeroVector, FRotator::ZeroRotator);
```

Note: Keep a reference to the spawned object if you want to remove it later

MORE ON BP OBJECT SPAWNING

- Must have access to the BP Class in order to spawn from C++
  - Create a property in .h to connect:

```
UPROPERTY(EditDefaultsOnly, ...)
UClass * myClassBP; //or TSubclassOf<MYBPClass>
```

  - Connect this pointer to BP class information
    - Use BP editor to connect this to requested class
    - Use `FObjectFinder/FClassFinder` to assign `myClassBP:`

```
static ConstructorHelpers::FClassFinder<UClass> myClass(pathtoBP);
if (myClass.Class)
  myClassBP = (UClass *)myClass.Class;
```

CONTEXT-SENSITIVE ABILITIES

- Abilities that are only available during certain times under certain conditions
  - Can implement using a combination of raycasts/trigger volumes and character **state** to determine how to interact

CHARACTER STATE

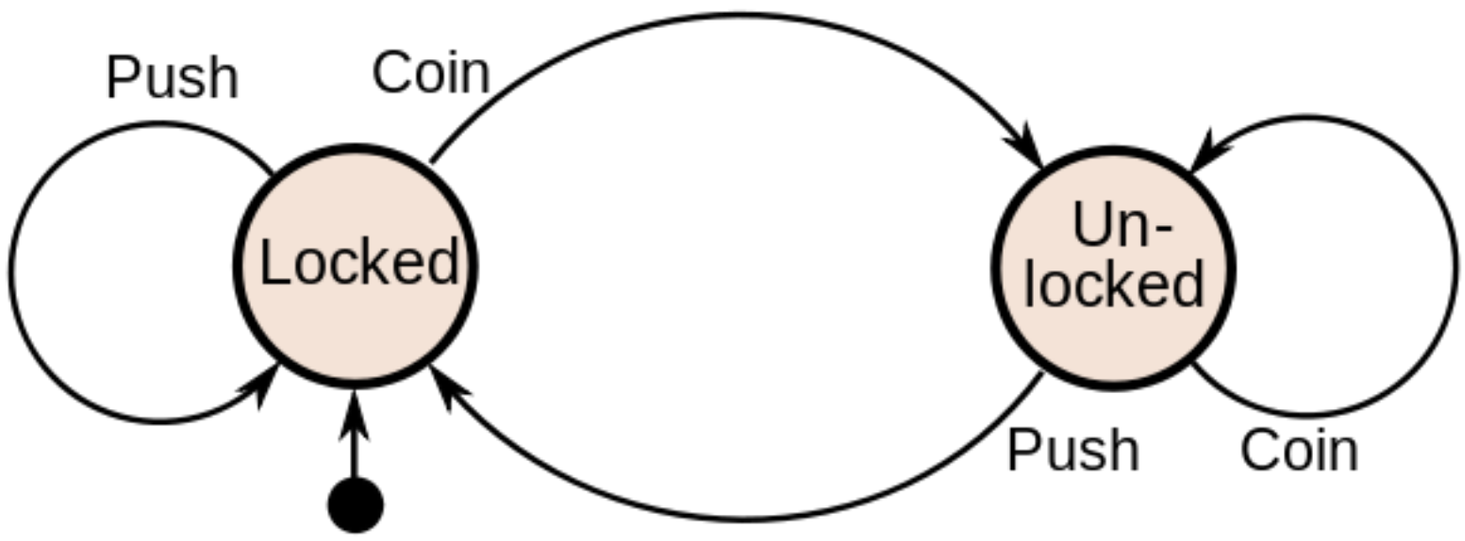
- Games are inherently very stateful
  - Awful for programming but it's what makes them engaging and dynamic
- Playable characters tend to have many different states as well
  - Idling, Walking, Running, Jumping, Dashing, Crouching, Diving, Interacting, Striking, On Cooldown, Taking Damage, Injured, Dying, Dead, etc...
  - Note that these states are not necessarily exclusive...

WHAT WE NEED TO KNOW...

- Can I transition from my current state to the requested state?
- How do I update my state?

FINITE STATE MACHINES (FSM)

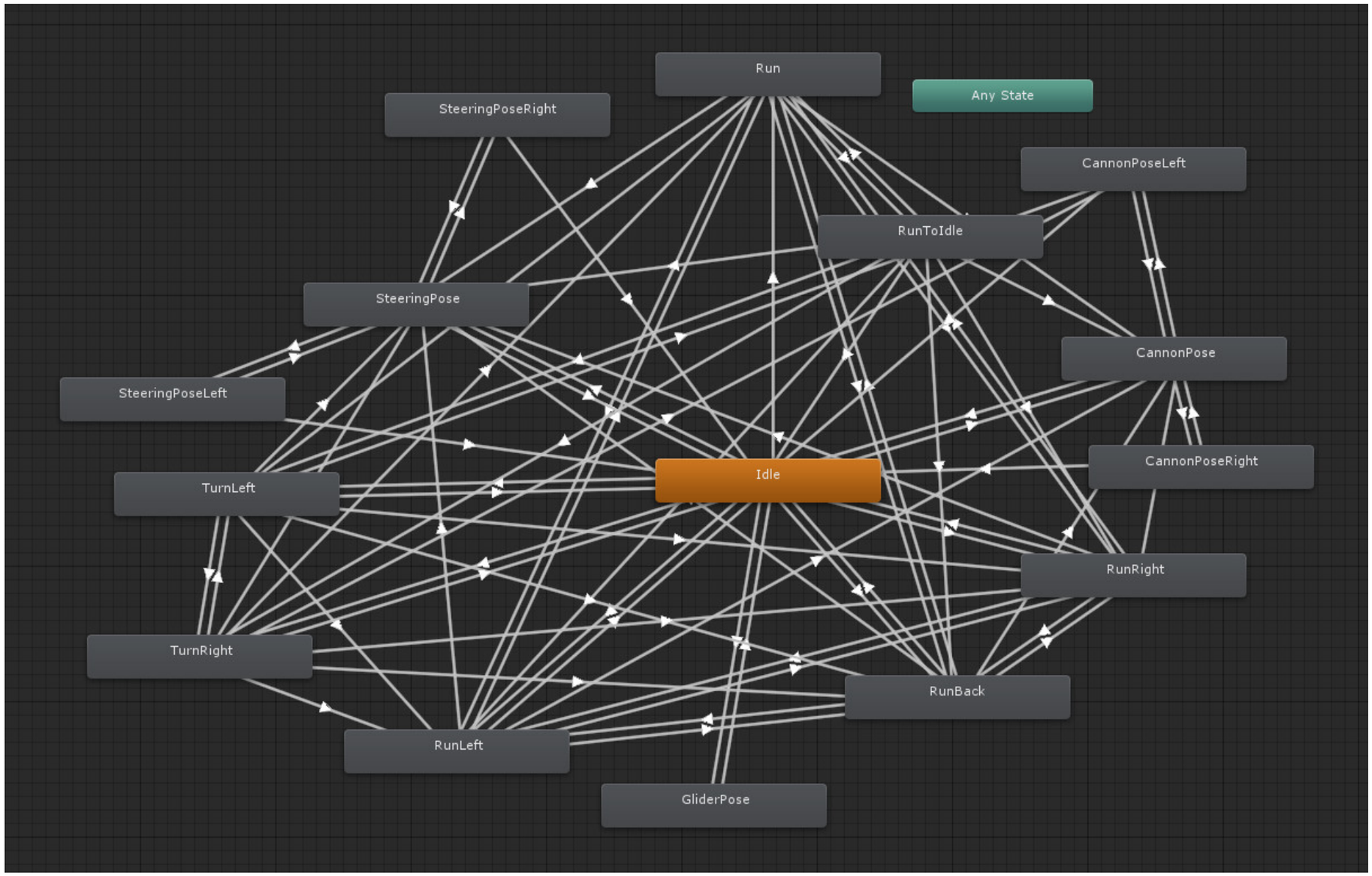
- Mathematical model of computation that describes a collection of states the machine can be in at any time
  - Must be in exactly one state
  - Can only transition between certain states



Wikipedia example: coin-operated turnstile

FSMS IN GAMES

Animation states for a character



https://www.gamasutra.com/blogs/HeikkiTormala/20121214/183567/Creating_fluid_motion_transitions_with_Unity_and_Mecanim.php

TRACKING CHARACTER STATES

- Possible to implement FSMs in a number of different ways (not implemented by default in Unreal outside of animations)
- Regardless of implementation, useful to connect to UENUMs so that enumerated states are exposed to Blueprints and AnimationBlueprints (more on that later)
- Also regardless of implementation, thinking through and *careful planning of* your states and transitions is essential for avoiding corner case bugs (which will happen regardless)

FURTHER READING

- <https://frametrapped.com/>
- <https://www.eventhubs.com/guides/2009/sep/18/guide-understanding-hit-boxes-street-fighter/>
- <https://gamecrate.com/how-e-sports-understanding-hitbox-meme/16773>
- <https://ringsandcoins.com/retrovision-street-fighter-ii-bug-that-changed-gaming-forever/>