State Pattern

Jumper Example

Lecture Task

- Point of Sale: Lecture Task 6 -

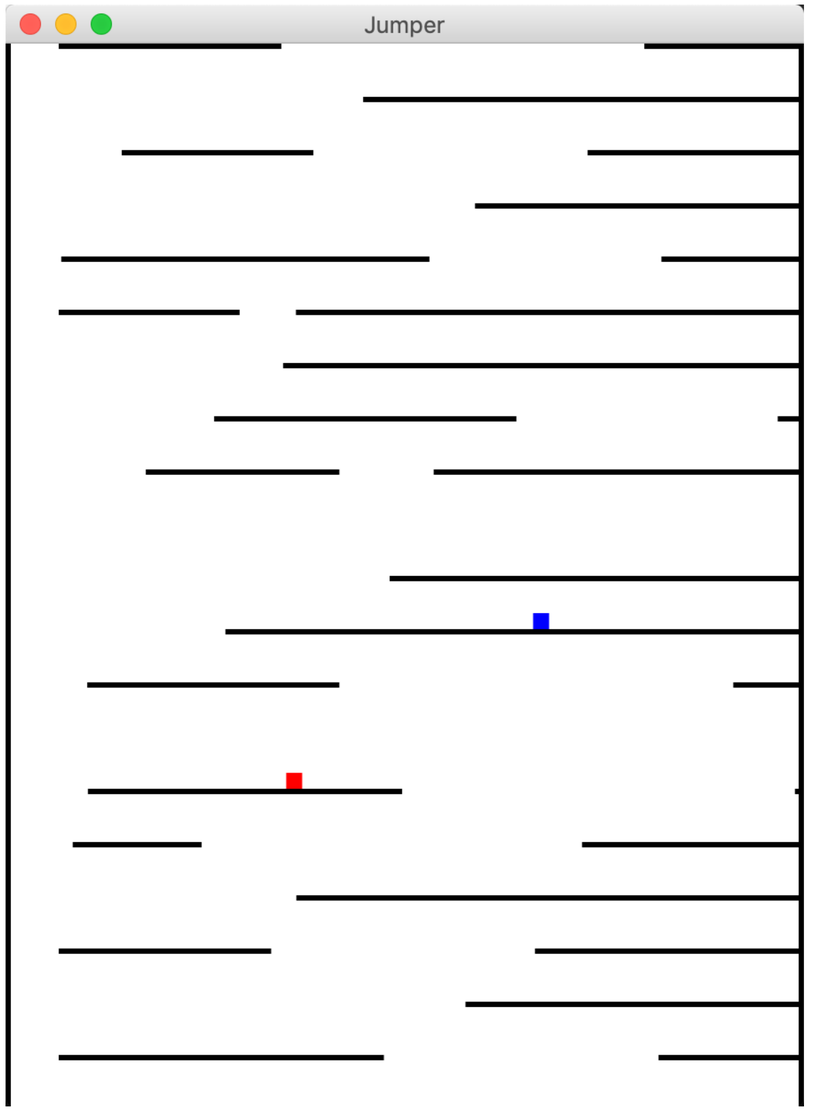
Functionality: As the customers interact with your self checkout machine, they should enjoy the following features:

- When the machine is first created it should display a String *containing* the word “welcome” to the customer (Example: “Hello and welcome to my store” **contains** “welcome” and is valid)
- When a customer enters an empty barcode, the previously entered item is “scanned” again
- When the customer presses the checkout button, they are indicating that they are ready to pay and:
  - No more items can be scanned
  - Display the exact String “cash or credit” to the customer
  - Add the following lines to the receipt in this order
    - Description “subtotal” with an amount equal to the sum of all the prices of the items that have been entered
    - Description “tax” with an amount equal to the sum of the tax of all the items that have been entered
    - Description “total” with an amount equal to the sum of the subtotal and tax
  - When the customer presses either the cash or credit button, display a string *containing* “thank you” to the customer, clear the receipt, and start accepting items again for the next customer

Testing: In the tests package, create a test suite named LectureTask6 that tests this functionality.

Jumper

- 2 Player vertical scrolling platform
- Screen scrolls up as the players climb the platforms
- The bottom of the screen is game over
- **Goal**: Climb faster than the other player



Jumper - Player

How does the player move?

- User inputs
- States! <-- Good stuff

Only 3 inputs to control each player

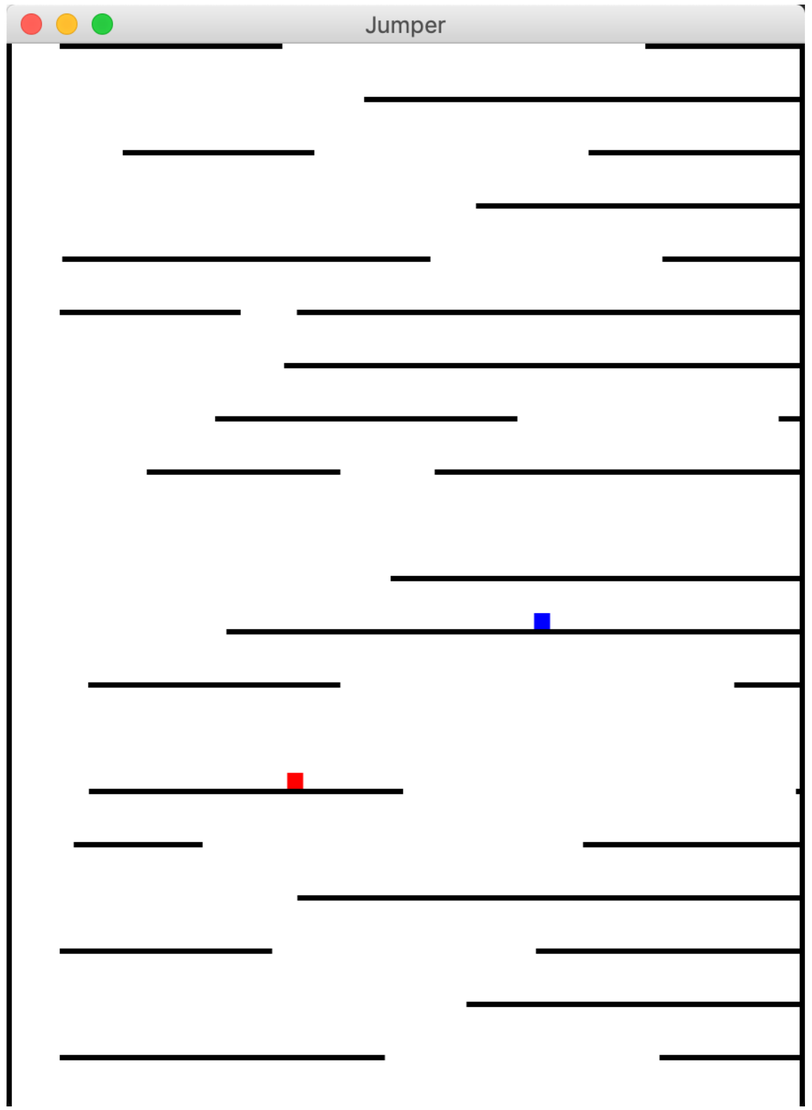
- Left button
- Right button
- Jump button

Player 1:

- a, d, w

Player 2:

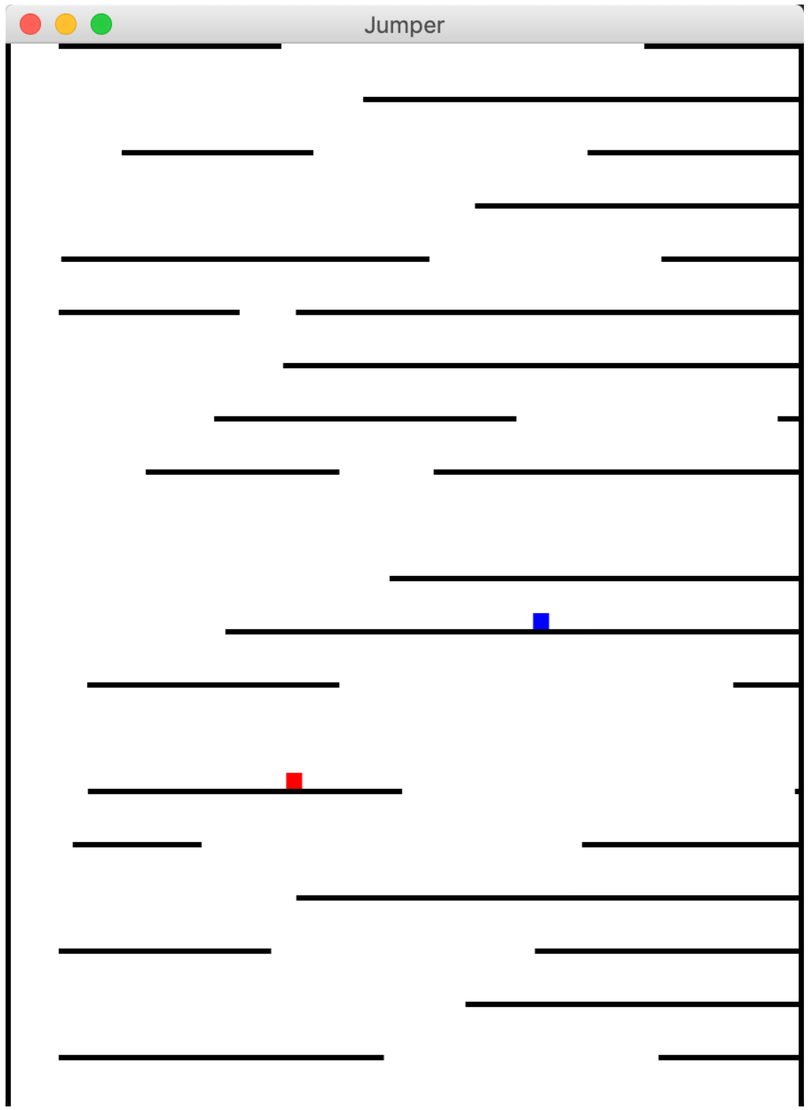
- Left, right, up arrows



Jumper Player Behavior

Each player should

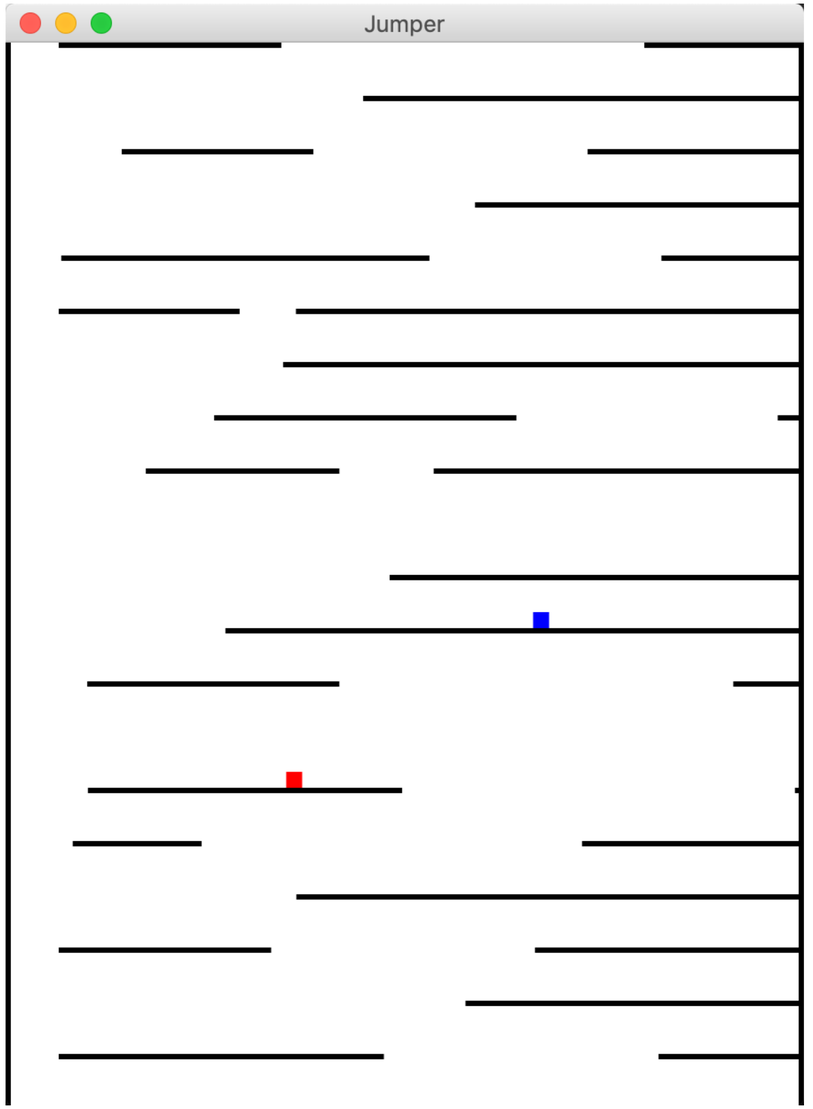
- Walk left and right when keys are pressed
- Jump when jump is pressed
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- Land on platforms while falling down
- Fall if walked off a ledge
- Block all inputs if the bottom of the screen is reached



Player behavior

We could write all this behavior without the state pattern

- Code will likely be hard to follow
- Difficult to add new features



Jumper Player Behavior

Each player should

- Walk left and right when keys are pressed
- Jump when jump is pressed
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- Land on platforms while falling down
- Fall if walked off a ledge
- Block all inputs if the bottom of the screen is reached

How to implement these features?

- Write your API
  - What methods will change behavior depending on the current state of the object
  - These methods define your API and are declared in the state abstract class
- Decide what states should exist
  - Any situation where the behavior is different should be a new state
- Determine the transitions between states

Jumper Player Behavior

Each player should

- Walk left and right **when keys are pressed**
- Jump **when jump is pressed**
- Jump higher if walking instead of standing still
- Jump at different heights based on **how long the jump button is held** after a jump
- Move left and right slower while in the air **if the direction is changed**
- Jump through platforms while jumping up
- **Land on platforms** while falling down
- Fall if **walked off a ledge**
- Block **all inputs** if the bottom of the screen is reached

How to implement these features?

- Write your API
  - What methods will change behavior depending on the current state of the object

API:

- left/right/jump pressed or released
  - 6 methods
- Land on a platform

Jumper Player Behavior

Each player should

- **Walk** left and right when keys are pressed
- **Jump** when jump is pressed
- Jump higher if **walking** instead of **standing** still
- **Jump** at different heights based on how long the jump button is held **after a jump**
- Move left and right slower while **in the air** if the direction is changed
- Jump through platforms while **jumping up**
- Land on platforms while **falling down**
- **Fall** if **walked** off a ledge
- Block all inputs if the **bottom of the screen is reached**

How to implement these features?

- Decide what states should exist

States:

- Standing
- Walking
- Jumping/Rising
- Falling
- Dead (Bellow Screen)

Jumper Player Behavior

Each player should

- **Walk left and right when keys are pressed**
- **Jump when jump is pressed**
- Jump higher if walking instead of standing still
- Jump at different heights based on how long the jump button is held after a jump
- Move left and right slower while in the air if the direction is changed
- Jump through platforms while jumping up
- **Land** on platforms while falling down
- **Fall if walked off a ledge**
- **Block all inputs if the bottom of the screen is reached**

How to implement these features?

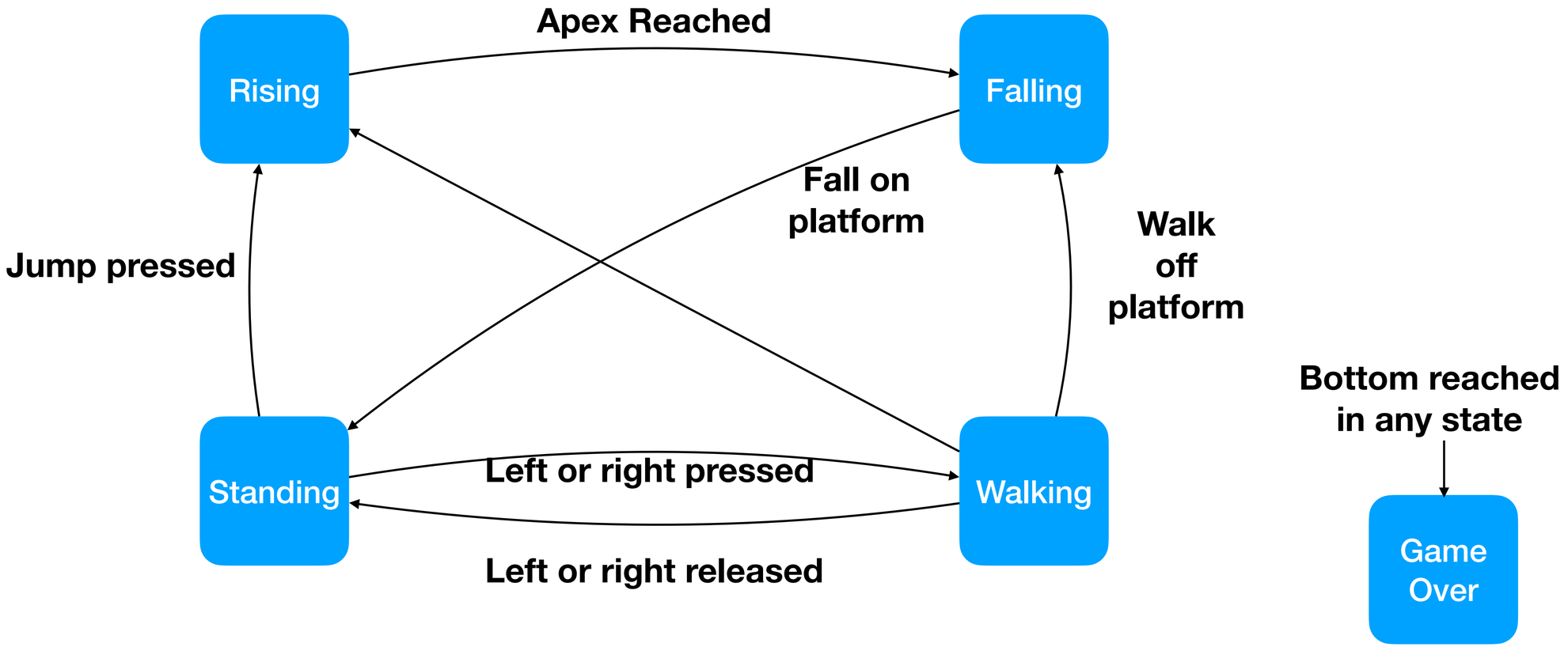
- Determine the transitions between states

State Transitions:

- Standing -> Walking
  - left/right pressed
- Walking -> Standing
  - left/right released
- Walking/Standing -> Jumping
  - Jump pressed
- Falling -> Standing
  - Land on a platform
- Walking -> Falling
  - Walk off a platform
- Jumping -> Falling
  - Apex of jump reached
- Any -> GameOver
  - Reach the bottom of the screen

Jumper Player Behavior

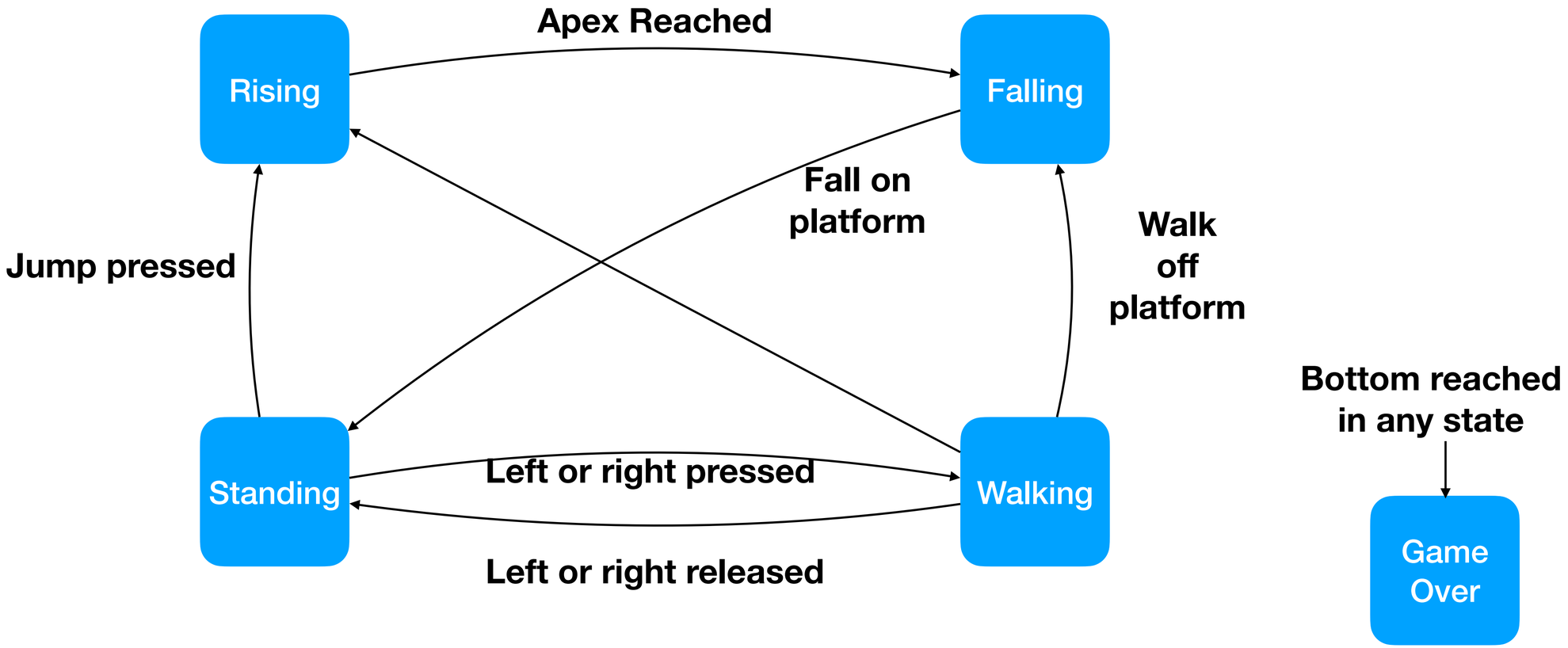
Let's visualize the states and transitions in a state diagram



Jumper Player Behavior

For each state, implement the API methods with the desired behavior in that state

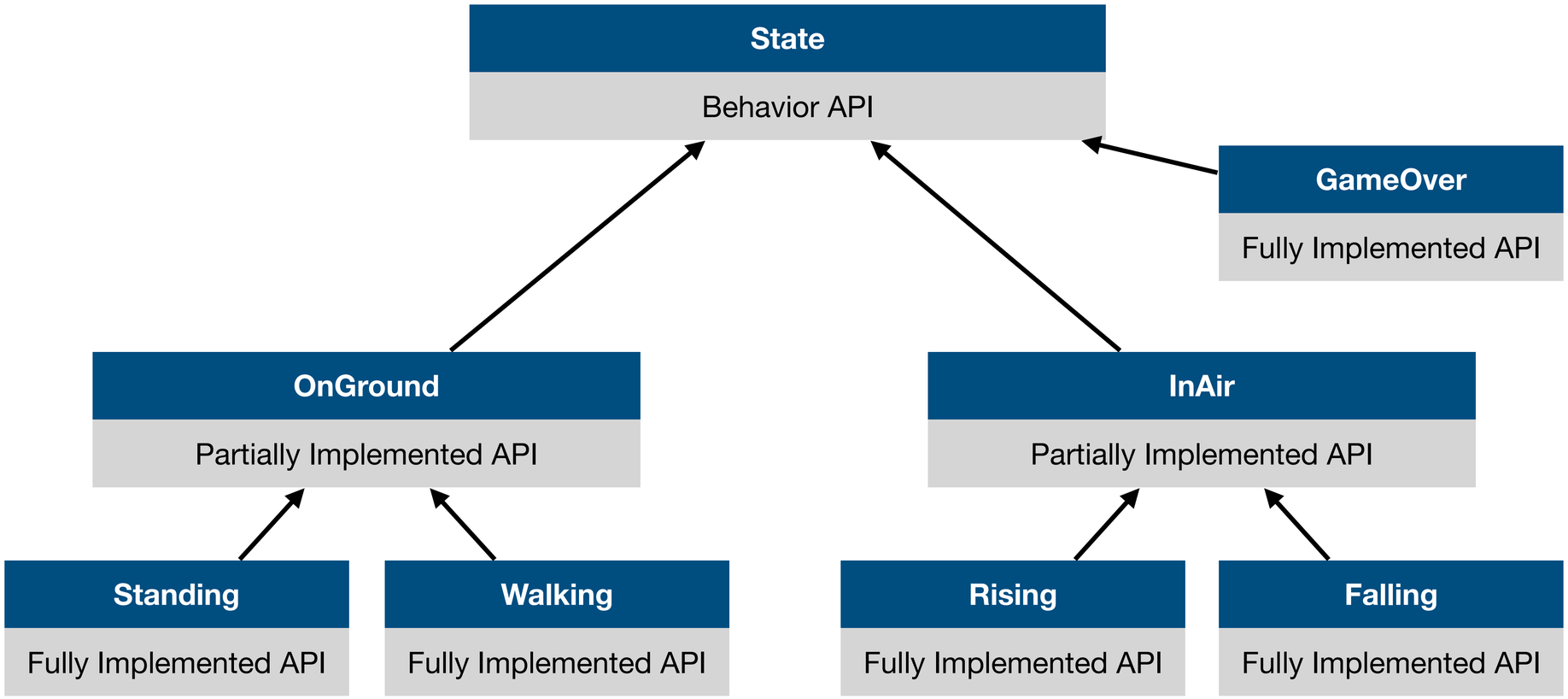
- Add default behavior in the state subclass



Jumper Player Behavior

Use inheritance to limit duplicate code

- Factor out common behavior between states into new classes



Adding Functionality

Task: Add a double jump to Jumper

- How can we add a double jump?
  - Players can jump 1 additional time while in the air

- With poor design
  - This could be extremely difficult!
  - May required modifying a significant amount of existing code

- With our state pattern
  - No problem at all

Adding Functionality

Task: Add a double jump to Jumper

- Add functionality to existing states
  - Rising and Falling states now react to the jump button by jumping again (Set velocity.z to the jump velocity)
- We'll add new states
  - RisingAfterDoubleJump/FallingAfterDoubleJump
  - Extend Rising/Falling respectively
  - Override the jump button press to do nothing
- Update state transitions
  - Press jump from Rising/Falling transitions to the respective AfterDoubleJump state
  - Reaching the apex in RisingAfterDoubleJump transitions to FallingAfterDoubleJump (Not Falling)

Adding Functionality

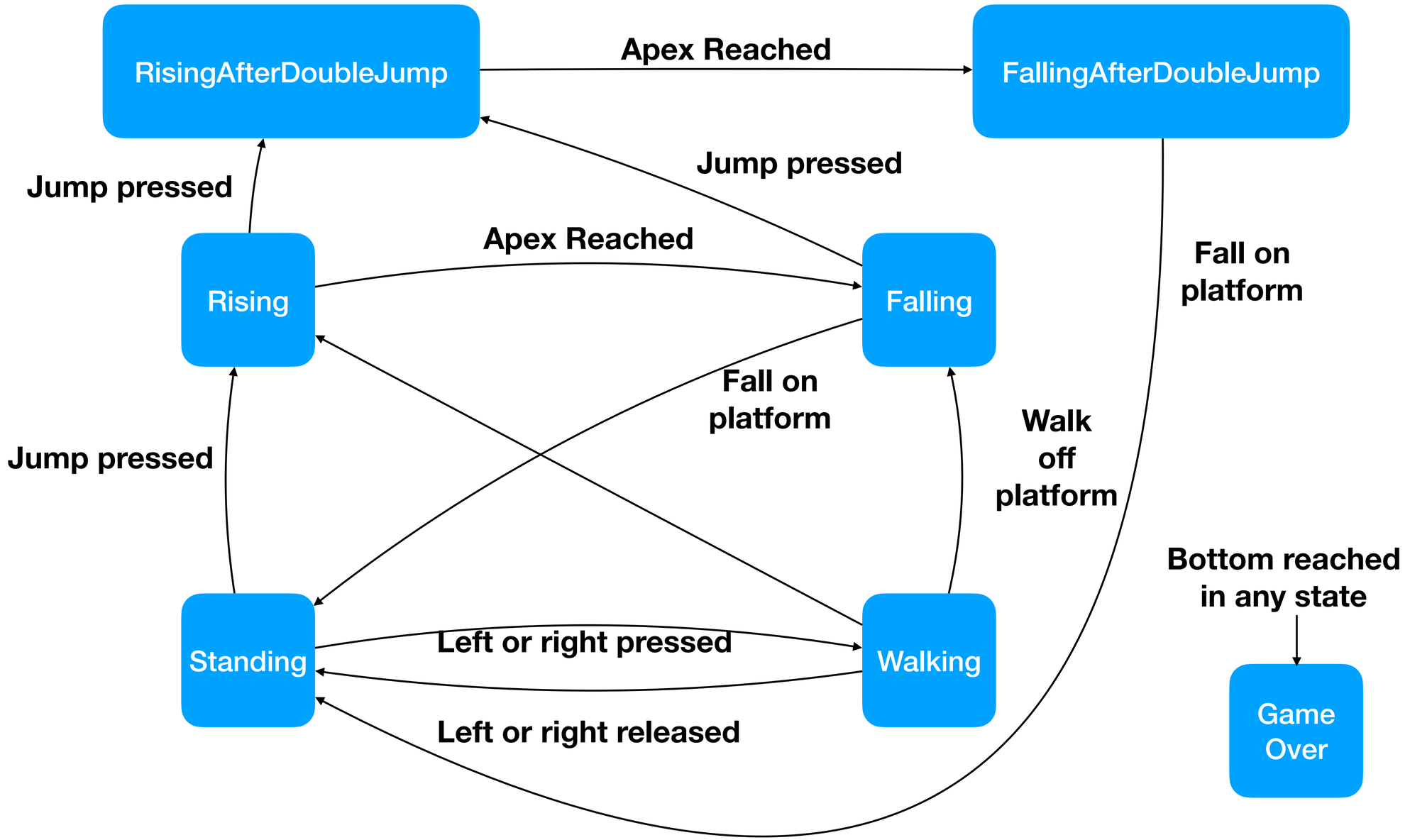
Task: Add a double jump to Jumper

- This task could have been completed with a boolean flag instead of using new states

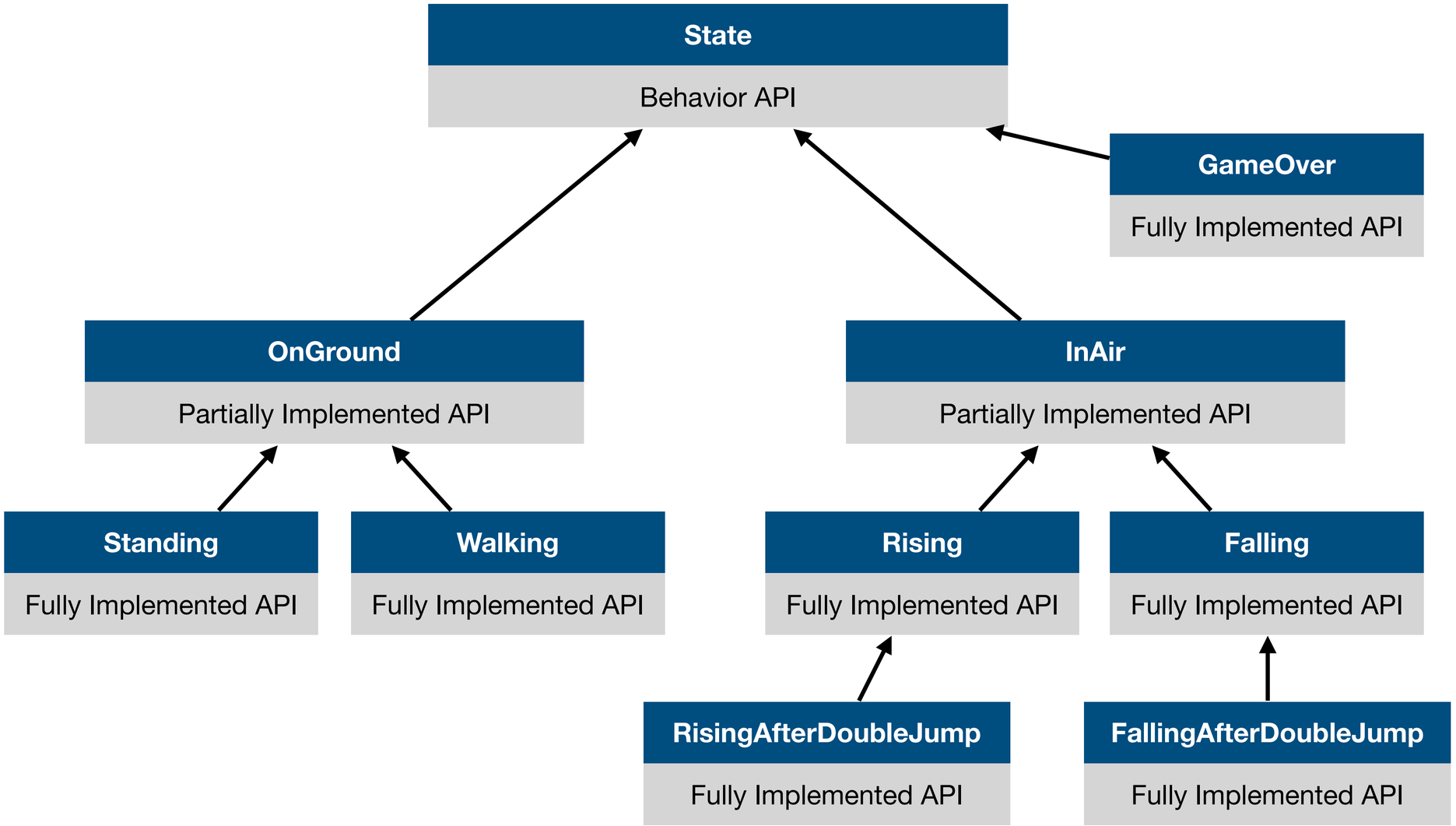
```
var usedDoubleJump = false

override def jumpPressed(): Unit = {
  if(!this.usedDoubleJump) {
    player.velocity.z = player.standingJumpVelocity
    this.usedDoubleJump = true
  }
}
```

- If this approach is used for many features the code will be harder to maintain
- **More to the point**: What if your professor says you can't use conditionals, but you have a situation where a button should only work once?
  - Try adding more states

Jumper Player Behavior



Jumper Player Behavior



State Pattern - Closing Thoughts

State pattern trade-offs

- **Pros**
  - Organizes code when a single class can have very different behavior in different circumstances
  - Each implemented method is only concerned with the reaction to 1 event (API call) in 1 state
  - Easy to change or add new behavior after the state pattern is setup
- **Cons**
  - Can add complexity if there are only a few states or if behavior does not change significantly across states
  - Spreading the behavior for 1 class across many classes can look complex and require clicking through many files to understand all the behavior

State Pattern - Closing Thoughts

- Do not use the state pattern everywhere
  - Decide if a class is complex enough to benefit from this pattern before applying it

- The state pattern in this class
  - I have to force you to use it by removing conditionals (Not realistic)
  - Used to reinforce your understanding of **inheritance** and **polymorphism**
  - Used as an example of a design pattern that can help organize your code
- When you're not forced to use this pattern
  - Weight the pros and cons to decide when it is the best approach

Lecture Task

- Point of Sale: Lecture Task 6 -

Functionality: As the customers interact with your self checkout machine, they should enjoy the following features:

- When the machine is first created it should display a String *containing* the word “welcome” to the customer (Example: “Hello and welcome to my store” **contains** “welcome” and is valid)
- When a customer enters an empty barcode, the previously entered item is “scanned” again
- When the customer presses the checkout button, they are indicating that they are ready to pay and:
  - No more items can be scanned
  - Display the exact String “cash or credit” to the customer
  - Add the following lines to the receipt in this order
    - Description “subtotal” with an amount equal to the sum of all the prices of the items that have been entered
    - Description “tax” with an amount equal to the sum of the tax of all the items that have been entered
    - Description “total” with an amount equal to the sum of the subtotal and tax
  - When the customer presses either the cash or credit button, display a string *containing* “thank you” to the customer, clear the receipt, and start accepting items again for the next customer

Testing: In the tests package, create a test suite named LectureTask6 that tests this functionality.