The Pragmatic Programmers

Advanced Hands-on Rust

Herbert Wolverson

edited by Tammy Coron

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CHAPTER 5

Build Reusable Game State Management

In *Hands-on Rust*, readers built and used the *Flappy Dragon* project as an introductory example to Rust game development. Flappy Dragon is similar to the classic—and popular—game, Flappy Bird. Instead of guiding a bird, players take on the role of a majestic dragon. Despite the character change, the primary objects remain the same: avoid obstacles and don't hit the ground.

Because the game logic and player controls are relatively simple, Flappy-like games are sometimes referred to as the "Hello, World!" of game development. These types of games aren't only fun to build but also extensible: you can add menus, game over screens, track scores, increase difficulty, and best of all, you can add your own visual flair.

Over the next four chapters, you'll build a new, graphical version of Flappy Dragon using both the Bevy engine and the library you built in Part II, Your First Library, on page ?. The initial setup is similar to the example from part one—so let's start with a premade base.

Setting Up Flappy Dragon

You can find the initial implementation of Flappy Dragon in the code/FlappyIntro/flappy_dragon_base/ directory of the accompanying source code. You'll also need my_library in the state it was in at the end of part one of this book. You can find it in the code/FirstLibraryDocs/my_library/ directory.

To get started, you'll need to create a new project for Flappy Dragon. Select a base directory and change the directory to it. Then, create a new project with Cargo:

```
⇛ cd (path)
⇛ cargo new flappy_dragon
```

Next, copy the source code into the new project structure:

1. Copy flappy_dragon_base (the directory, not just the contents) into the (path)/flappy_dragon directory from code/FlappyIntro/flappy_dragon_base/.
2. Copy my_library (again, the directory) into the code/FirstLibraryDocs/my_library/ directory.

You should now have a directory structure that looks like this:

```
(path)
   flappy_dragon
      flappy_dragon_base
         assets
         src
         Cargo.toml
      my_library
         src
         Cargo.toml
      src
      Cargo.toml
```

Let's add flappy_dragon_base and my_library to the top-level workspace. Open (path)/flappy_dragon/Cargo.toml and add the following lines to the [workspace] section:

```
[workspace]
members = [
    "flappy_dragon_base",
    "my_library"
]
```

It's always a good idea to warn users when they try to run the top-level workspace. Open (path)/flappy_dragon/src/main.rs and change it to warn the user that they're trying to run the top-level workspace:

```
fn main() {
    println!("Please run the flappy_dragon_base project instead.");
}
```

Finally, link the library to the project. Open (path)/flappy_dragon/Cargo.toml and add the my_libary and bevy to the [dependencies] section:

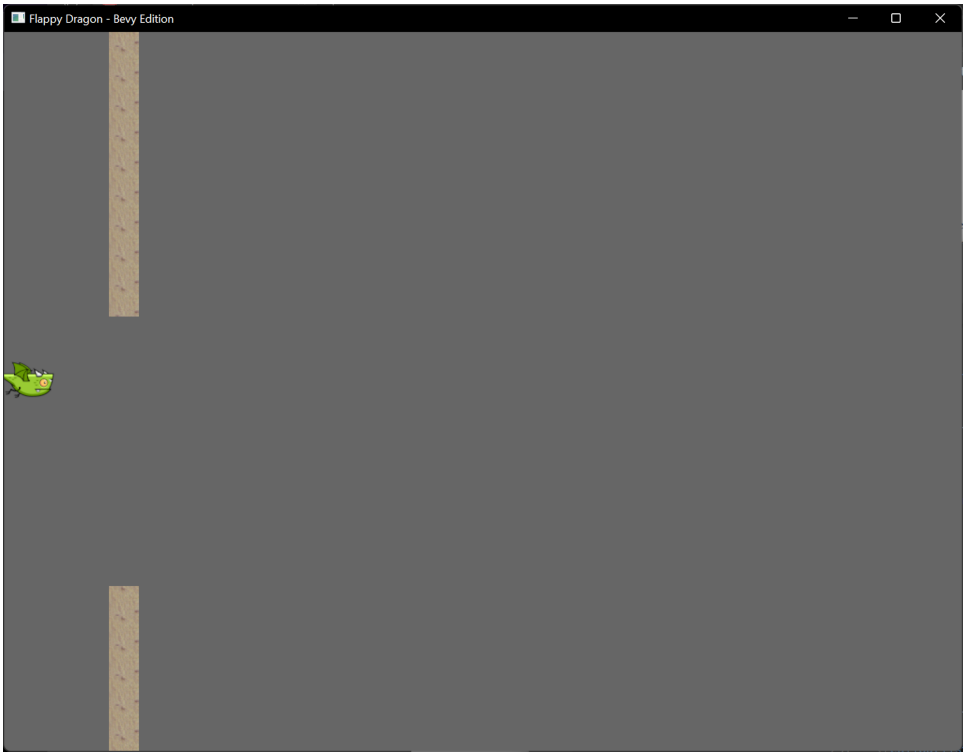
```
[package]
name = "flappy_dragon_base"
version = "0.1.0"
edition = "2021"

[dependencies]
bevy = "0.16"
my_library = { path = "../my_library" }
```

You can now run the project:

```
⇛ cd (path)/flappy_dragon/flappy_dragon_base
⇛ cargo run
```

The game should start and look like this:



Paths in the Downloaded Source Code

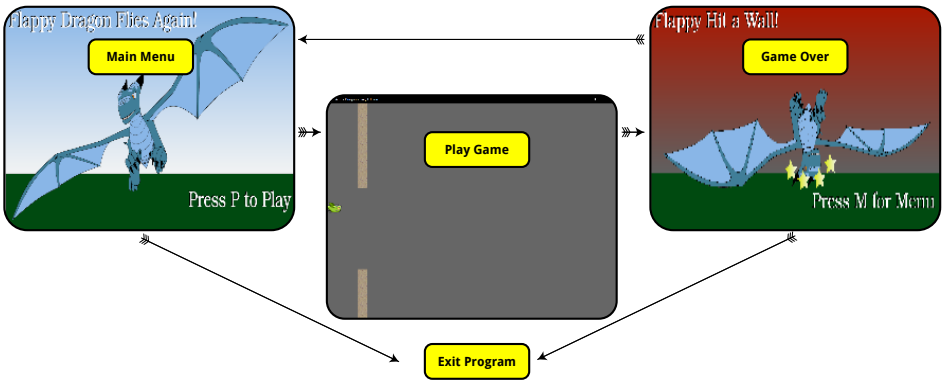
The downloadable source code includes multiple versions of both flappy_dragon_base and my_library. The Rust workspace system doesn't like it when projects have the same name inside a workspace, so the downloadable version changes project names in Cargo.toml. As you follow along with the book, update your project and keep the names the same, which will make it easier to follow along.

Understanding the Flappy Dragon Code

This implementation doesn't include anything you haven't already used in the book so far, so there's not much to explain. However, you need to know some things before you get started with the updates.

Flappy Dragon uses two graphics, both located in the assets directory. The dragon graphic is freely available from OpenGameArt.[1] The wall graphic was quickly put together in the Gimp.[2]

Most games follow a similar overall game cycle that includes an optional loading screen, a main menu, playing the game, and finally a game over screen. When players reach the game over screen, they typically either exit the game or play again. You can visualize this game cycle as follows:



In this chapter, you'll create the main menu and game over screens for Flappy Dragon and Pig. More specifically, you'll build a reusable menu system suitable for inclusion in any game you create, as you'll see when you add these items to Pig (you'll do this near the end of the chapter). As you work through this chapter, you'll learn more about generics, traits, and state management. You'll also learn how to use macros to shorten complicated syntax.

Understanding Bevy and Game States

Before you create your state management system, it's worth taking a moment to study how Bevy handles application state. At the top level, a Bevy game maintains a state variable. State is stored as a resource and can be accessed in systems. And Bevy's scheduler uses the game's state to determine what systems to run.

States operate in phases:

- When a state becomes active, systems attached to its `OnEnter` phase run.
- With every "tick," the active state's `Update` systems are executed.
- When a state is deactivated, systems contained in the state's `OnExit` run.

1. https://opengameart.org/content/flappy-dragon-sprite-sheets
2. https://www.gimp.org/

You specify which systems run for each state in your app builder by adding *system sets*. We'll model GameState as an enumeration—it isn't provided by Bevy; you'll have to make one to represent *your* game state. In this example, we've added a PlayMyGame state to illustrate how states can be connected to Bevy systems:

```
// System runs for all states
.add_systems(Update, System1)

// System runs when State becomes active
.add_systems(OnEnter, setup.run_if(in_state(GameState::PlayMyGame)))

// System runs each tick State is active
.add_system(OnUpdate, run.run_if(in_state(GameState::PlayMyGame)))

// System runs when State becomes inactive
.add_system(OnExit, exit.run_if(in_state(GameState::PlayMyGame)))
```

As a rule of thumb, try to make states self-contained.

A state should perform the setup and tag entities as belonging to the state. When the state exits, it should clean up any entities tagged as belonging to that state. This ensures that states can operate independently, which is especially important in a library, since you—the author—have no idea what a library consumer might do in the states you didn't design.

Modeling Game State

Let's start by organizing the code in my_library.

You're building a *framework* to handle game flow, so create a module named bevy_framework. The framework will include multiple modules, so let's put it inside a folder. Create a new directory named my_library/src/bevy_framework. In that folder, create an empty file named mod.rs. Now, include the file in my_library by opening my_library/src/lib.rs and adding the following code:

```
mod bevy_framework;
pub use bevy_framework::*;
```

bevy_framework is now part of my_library, and it exports any public members to library consumers.

Engines vs. Frameworks

A framework is a skeleton organization, while an engine actually does the work. Bevy is an engine: it takes control of your program and requires that you work within its idioms. A framework is more forgiving, offering a suggested approach to a task.

Flappy Dragon is a simple game: you're either playing the game or you're not. Adding in menus, you can model the states as follows:

```
#[derive(Clone, Copy, PartialEq, Eq, Debug, Hash, Default, States)]
enum GamePhase {
➤   MainMenu,
    Flapping,
➤   GameOver,
}
```

Pig is a bit more complicated, with several states that activate while the game is running. Pig's game phase enumeration will need expanding to also include the game menus:

```
#[derive(Clone, Copy, PartialEq, Eq, Debug, Hash, Default, States)]
enum GamePhase {
➤   MainMenu,
    Start,
    Player,
    Cpu,
    End,
➤   GameOver,
}
```

Adding the `MainMenu` and `GameOver` items brings a little complexity to your workflow—but don't worry, you're going to automate most of the work of using them in your library. Let's start building a state management plugin for Bevy.

Layered States

Before version 0.11, Bevy supported nesting states inside other states and states with parameters. The Bevy Engine team decided on a simpler state system. It works fine, but you'll have to add generic states into your state enumeration every time.