Design and Implementation of Virtual Physics Based on Unity and Visual Programming

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Abstract. Based on the Unity3D physical simulation characteristics and PlayMaker visual programming as the programming means, this paper designs and realizes the virtual experiment suitable for junior high school physics teaching. The purpose is to transform the serious physical experiment into an intuitive and vivid virtual interactive animation, so as to stimulate students' interest in physics learning and improve the learning quality.This design is mainly designed for the elastic realization and gravity experiment in the middle school physics curriculum.In addition, the use of visual programming tools can reduce the development threshold, and some non-computer major students can also complete the design and implementation of the experiment in practice.

Keywords: Unity3d; virtual physics experiment; visual programming.

1. Physical properties of the Unity engine

Physical engine is the engine that simulates collisions and falls in the real world.It is a computer program to simulate Newtonian mechanical models, using variables such as mass, speed, friction, and air resistance.It can be used to predict the effect in this different case.It is mainly used in computational physics and video games and computer animation.According to the field applied, the physical engine is generally divided into two types, namely real-time physical engine and high-precision physics engine.High-precision physics engines require more processing power to calculate very accurate physics, often used in scientific research (computational physics) and computer animated films.Real-time physical engines use commonly used in video games and simplify operations, reduce accuracy to reduce computation time, and get processing speeds acceptable in video games.(As shown in Figure 1)

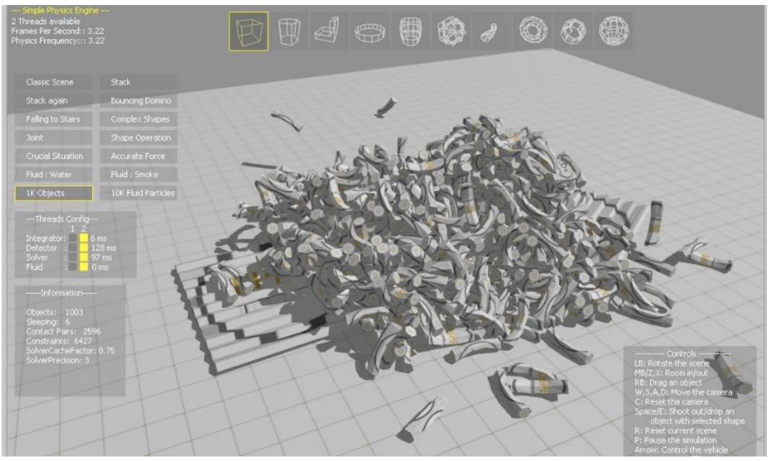

Figure 1. Physical engine

The use of Unity 3D can provide students with a realistic 3 D perspective, and it is itself a physical engine. The performance of physical phenomena is not a 3 D animation preset by the producer, but that the experimenter can assign any value to the variables arbitrarily, and then truly simulate the physical phenomena in the real world through the computer.This makes the phenomena and results of physical virtual experiments both real and accurate, which are currently inaccessible to other types of software.The real three-dimensional perspective consists in the interconnection between experimental parameters and experimental phenomena, which can not only help students to deeply understand and master the knowledge points, but also give full play to their imagination and exploration spirit. Moreover, due to the accuracy of the experiment, it can also exercise students' rigorous scientific attitude.(As shown in Figure 2)

Figure 2. Unity Game Engine

2. Introduction to the PlayMaker visual programming

PlayMaker was developed by Hutong Games, a third-party software developer, Hutong Games.Its Logo is a Chinese word for "play".(As shown in Figure 3) It is both a visual scripting tool and a hierarchical logic framework.Designers and programmers use PlayMaker to quickly complete the prototype games, suitable for independent developers and especially for teamwork.It has many advantages. First of all, it can make a lot of actions, such as running, jumping, attack and so on.It can only be achieved through a simple state machine FSM (Finite state machine), without writing a sentence of code, which greatly lowers the threshold for some non-computer professional related practitioners or enthusiasts to develop game prototypes.Second, it relies on convenient and simple charts to manage each state machine.It also supports all kinds of Unity plug-ins to accelerate the development process.At present, many games are also based on PlayMaker, such as for example, the card Hearthstone online game produced by Activision Blizzard Game Entertainment recently acquired by Microsoft, and 70% of the content is developed by PlayMaker.(As shown in Figure 4) Due to the functional requirements of this project are relatively simple, and more of the physical characteristics of Unity3D, so the PlayMaker visual programming tool can be quickly and intuitively completed.

Figure 3. The Playmaker Visual Programming plug-in

Figure 4. Game "Hearthstone"

3. Development status of physics experiments in middle schools

Experimental teaching is one of the essential links in middle school physics teaching activities, and the experimental teaching link is crucial for middle school students to learn and apply physics knowledge. Physics is mainly composed of experimental and theoretical parts. Physics experiment is an important way for human beings to understand the world, and it is also the basis of scientific research. It is not only an important foundation of middle school physics teaching, but also an important content, method and means of middle school physics teaching.The main purpose of using the experiment in middle school physics teaching is to be able to create a good environment for students to learn physics courses, improve the enthusiasm of students to obtain physics knowledge and development ability, initiative, and to all kinds of physical phenomena can intuitively show, rather than a single book textbook abstract explanation.With the continuous deepening of the new curriculum reform and the continuous growth of the national investment in compulsory education, the construction of software, hardware and resources and equipment of compulsory education have been greatly improved, and these changes have brought rare development opportunities for the physics experimental teaching in middle schools.However, the development of physics experiment teaching in traditional middle schools still has various shortcomings.For the economically developed areas, the hardware facilities of the schools are relatively perfect, which can not only show the physical phenomena through experiments, but also enable every student to participate in the experiment.However, for some economically underdeveloped areas, the experimental equipment is relatively old, and more physical phenomena are explained through videos and pictures. Sometimes, because the content is too abstract, many students cannot understand it, which may hit students' interest in physics from the very beginning.

Article 32 of the Key Points of Work of the Ministry of Education in 2006 mentioned that "strengthening the construction of application projects such as digital libraries, digital museums and virtual laboratories".It can be seen that the Ministry of Education attaches great importance to the virtual reality technology.Compared to the traditional experimental teaching, virtual experiment can give students more hands-on opportunities, students can use the virtual experiment system before learning new lessons, and after learning new courses can also use the virtual experiment system to review, consolidate, virtual experiment can play the role of auxiliary traditional experimental teaching (as shown in Figure 5).Through the virtual experiment, the students will have a deeper understanding of the confirmed physical phenomenon in the process of learning physics, improve the teaching quality; stimulate the interest in learning; and ensure the safety of the teaching experiment.

Figure 5. Virtual experiment class

4. Design and implementation of physical virtual experiments

4.1. Design and implementation of magnetic virtual experiment

4.1.1. Virtual experiment design:

Magnetic force is a kind of interaction force, the magnet itself does not have a magnetic force, is the result of the interaction between the two magnets, which can be manifested as the repulsion and gravity.This experiment set two objects, one object a variable pole, expressed in yellow, and the magnetic force and magnetic pole can be controlled by the slider, and the object is fixed to the ground.The other object is a magnetic object and the magnetic pole of the object is order N, indicated in red.To ensure authenticity, friction needs to be added to both the ground and to the objects.This experiment hopes to show the physics of magnetic force-specific phase absorption and homogeneous phase repulsion through the slider. When the slider is at the midpoint, the yellow object is not magnetic at this time, and the red and yellow two objects remain inactive in situ.When the slider is drawn to the right, the magnetic pole of the yellow object is level N, and the red and yellow objects are rejected. If the slider is drawn to the left, the magnetic pole of the yellow object is level S at this time, and the red and yellow objects have mutual suction.The whole implementation design sums it up, and its purpose is to show the characteristics of magnetic force-specific phase absorption and homogeneous phase exclusion through the form of virtual experiment.(As shown in Figure 6)

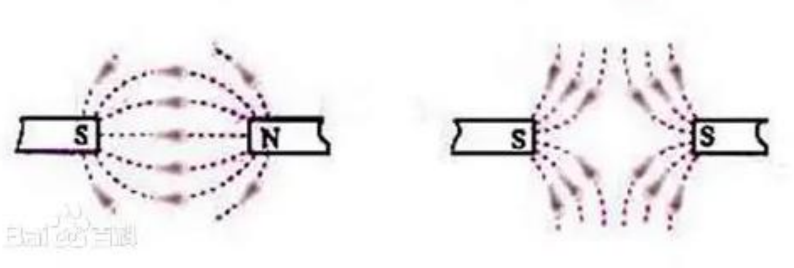

Figure 6. Magnetic force

4.1.2. Virtual experiment implementation:

Open Unity3D, search PlayMaker via Unity official Asset Store, click download and install (shown in Figure 7).The option for PlayMaker appears in the option above the Unity Editor (as shown in Figure 8) after installation, proving that PlayMaker has been successfully installed.

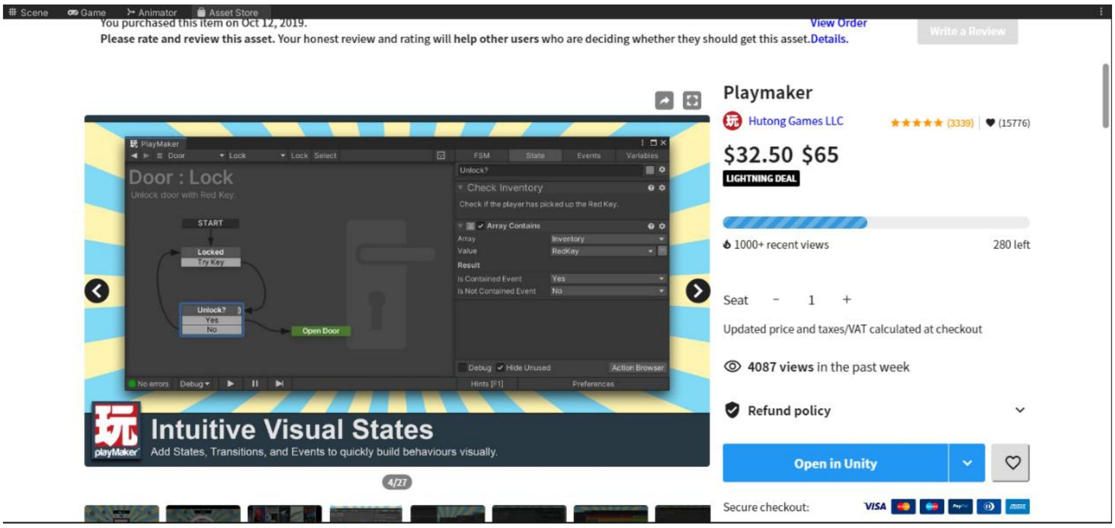

Figure 7. Unity Asset Store

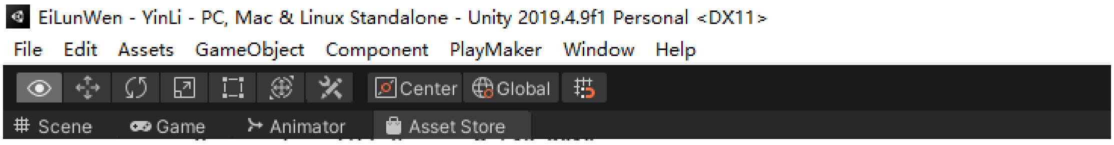

Figure 8. The PlayMaker options in the menu bar

Create planes and two spheres in the editor, add different color and physical materials to two spheres and planes (shown in Figure 9) to two red and yellow spheres, which gives them physical properties, and later operation must also require the object to be rigid (as shown in Figure 10).To add the yellow sphere, first select the yellow sphere, open the PlayMaker editor, right-click in the blank, and select "Add FSM" (as shown in Figure 11).Add Action in the State window and click PlayMaker option> Editor Windows> Action Browser (shown in Figure 12).Find the GUI Horizontal Slider (GUI horizontal slide), Get Position (get position), Explosion (blast force) (in the ejected Action Browser, as shown in Figure 13).Since there is no Action that specifically simulates magnetic force in PlayMaker, but Explosion can well simulate the effect of magnetic force, only changing the direction of the force to show the physical phenomenon of homogeneous phase exclusion and specific phase absorption.Set the 3DVector variable P, through Get Position, the P point position, the magnetic core position, can be obtained in real time.Set the Float-type variable F, by which one controls the force size (as shown in Figure 14).

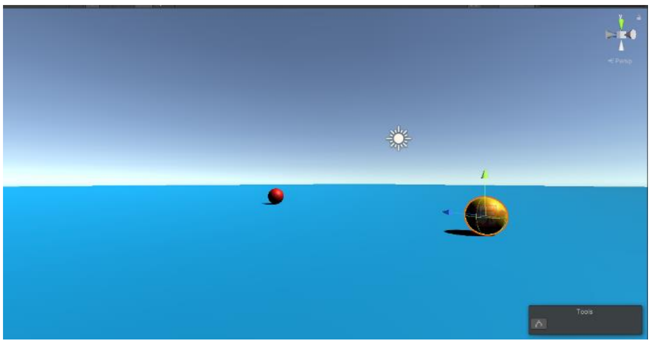

Figure 9. Red and yellow ball in the experimental scene

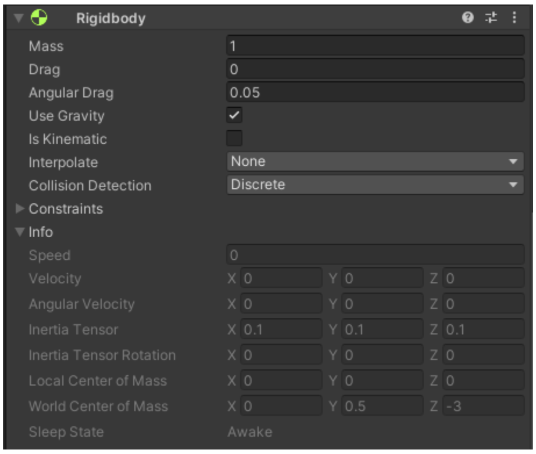

Figure 10. The rigid body assembly

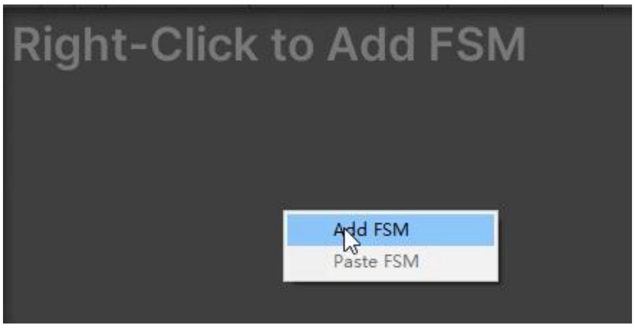

Figure 11. Add the FSM

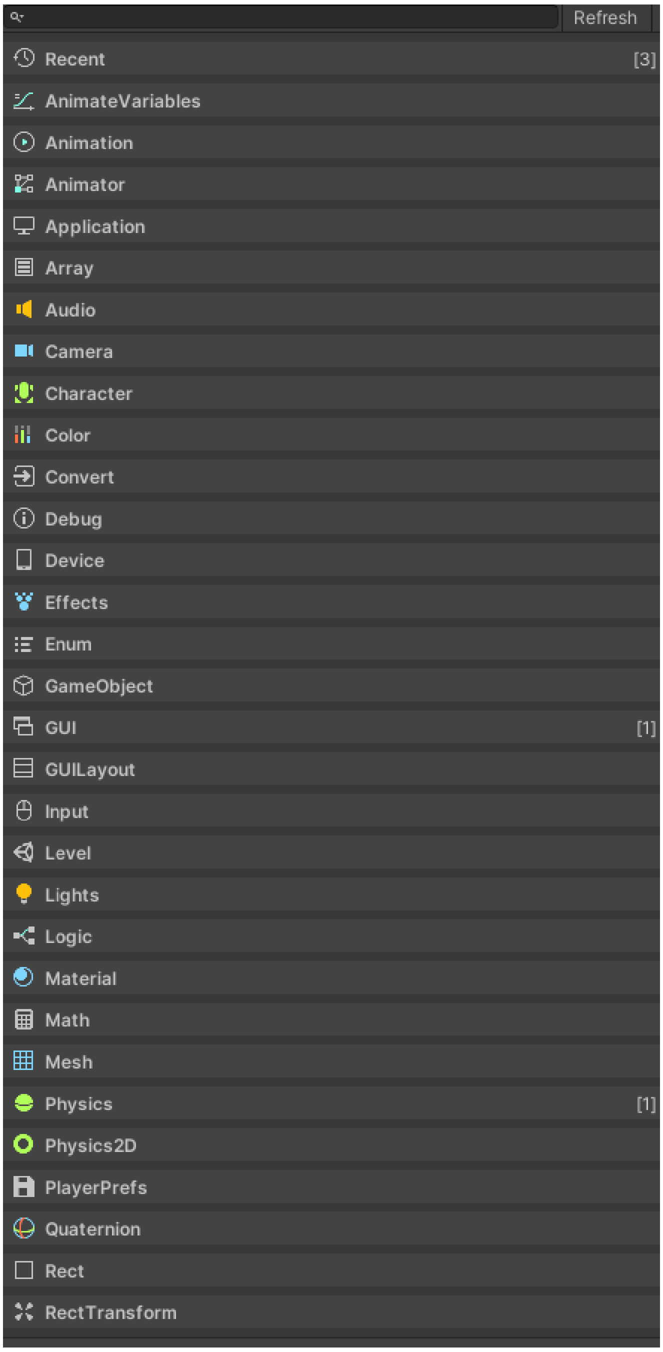

Figure 12. Action

Figure 13. Three required Action s

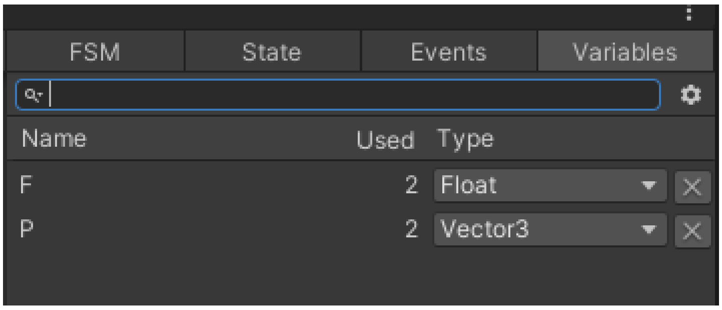

Figure 14. Set the variables

① adds the GUI Horizontal Slider settings as follows (as shown in Figure 15):

Float Variable: Set to variable F (this value is the previously set Float type variable);

Left Value: -15 (-15 when the slider is at the center of the slider, 0 and at the far left end of the slider);

Right Value: 15 (15 when the slider is 0 at the center of the slider and at the far right end of the slider);

The following is the setting of the slider location:

Left：0.25；Top：0.25；Width：0.5；Height：1。

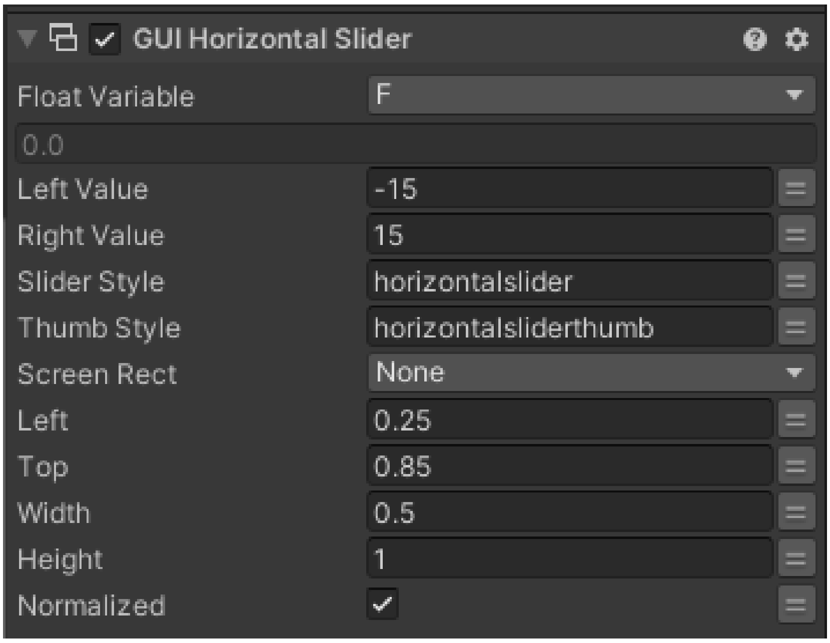

Figure 15. GUI Horizontal Slide settings

② adds the Get Position settings as follows (as shown in Figure 16):

Game Object: Set to Use Owner;

Vector: Set to variable P (this value is the previous set type 3DVector variable P);

Check the Every Frame (make sure each frame gets the P point location information in real time).

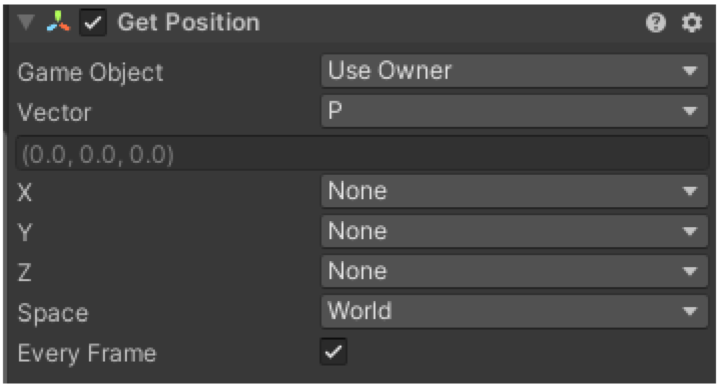

Figure 16. Get Position settings

③ adds the Explosion settings as follows (as shown in Figure 17):
Center: Set to variable P (this value is the previous set type 3DVector variable P);
Force: Set to variable F (this value is the previous set Float type variable);
Check the Every Frame (make sure each frame gets the P point location information in real time).

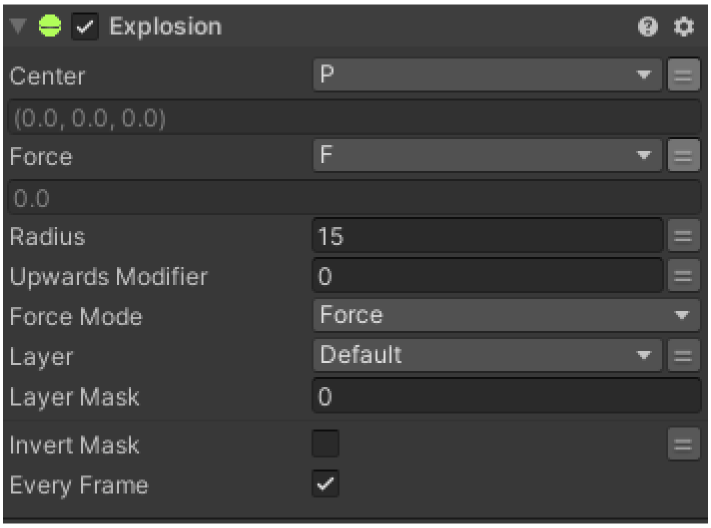

Figure 17. Explosion settings

Programming structure of the entire virtual experiment (as shown in Figure 18).

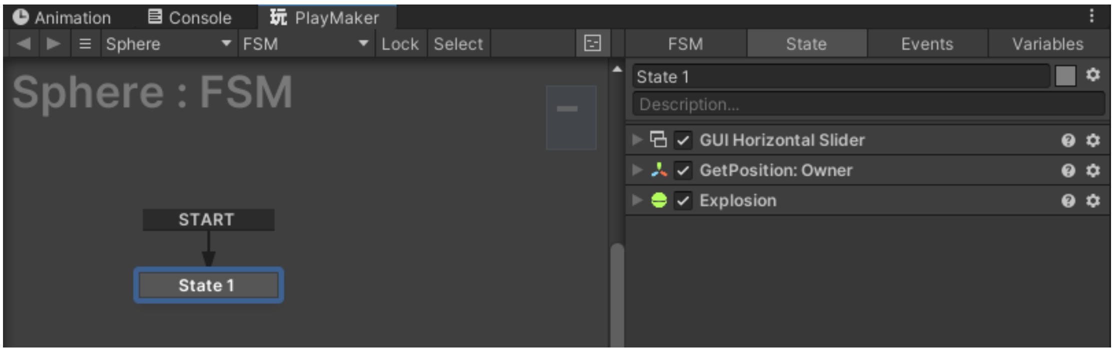

Figure 18. Overall programming structure

4.2. Design and implementation of gravitational virtual experiment

4.2.1. Virtual experiment design:

Gravity, the attraction of any two objects or between two particles associated with its mass product, is the most universal force in nature, simply gravity.This virtual experiment is intended to explain the relationship between gravity and the height from the Earth by simulating the satellite scene around the Earth, thus indicating that the phenomenon of gravity is different in different sizes and heights of forces. The first is to simulate the rotation phenomenon of the earth first. Then, water smoothing strips were used to control the power of the satellite in the horizontal direction, using vertical sliding strips to simulate the height of the satellite from the surface. If the satellite is too close to the Earth or the force of the satellite is too small, it cannot surround the earth, and the satellite will intersect with the earth. If the height or force reaches a certain value, the satellite can successfully complete the ring movement. Through this experiment, the image shows the most common force in nature, and also explains the physics of mutual encircling between planets and satellites.

4.2.2. Virtual experiment implementation:

After PlayMaker is installed, the Earth model is downloaded through the Unity Resource Store, a free resource (as shown in Figure 19). After the resource is imported, a folder named Plant Earth Free appears in the Project window (as shown in Figure 20), find the model file of the name EarthHigh in the folder (as shown in Figure 21), and click Create the Earth Model.Since the resource itself has a code script for the Earth rotation, but this virtual experiment requires PlayMaker visual programming to simulate the rotation of the Earth, the code script is unchecked (as shown in Figure 22).Then create a satellite, create a new sphere in Unity, and change the material to red, quadruple the size, and change the name to StateLite (as shown in Figure 23).Add both Earth and satellite models, and by simulating the space environment, uncheck the gravity option in the rigid body assembly (as shown in Figure 24).Right-hand to create a new "Game Object" object that is used to store the contents of the interactive part of this virtual experiment.So far, the digital resources of this virtual experiment have been fully prepared.

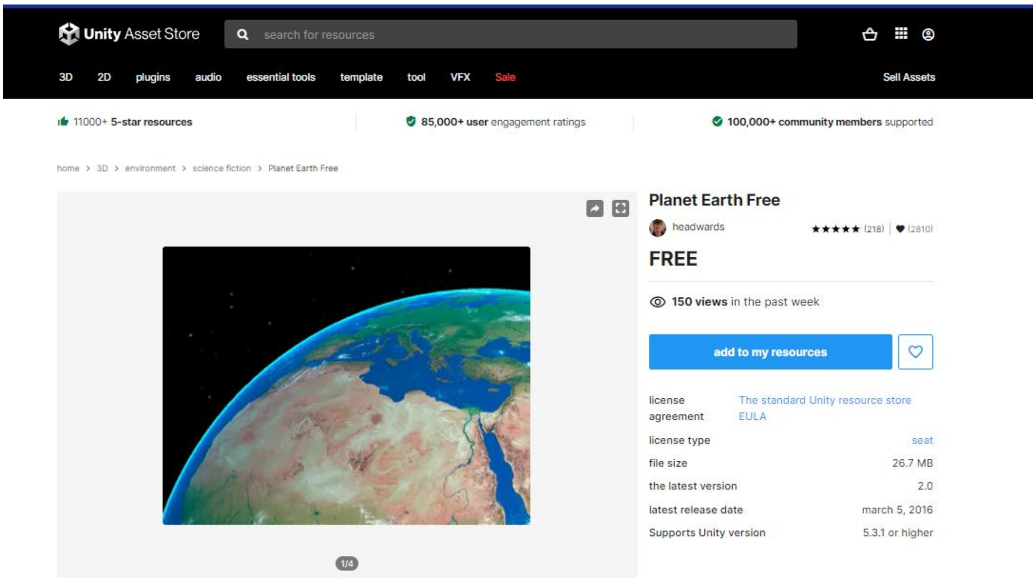

Figure 19. The Plant Earth Free resource

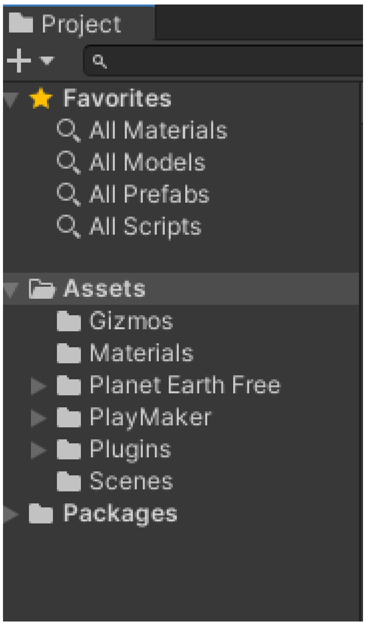

Figure 20. Resource import

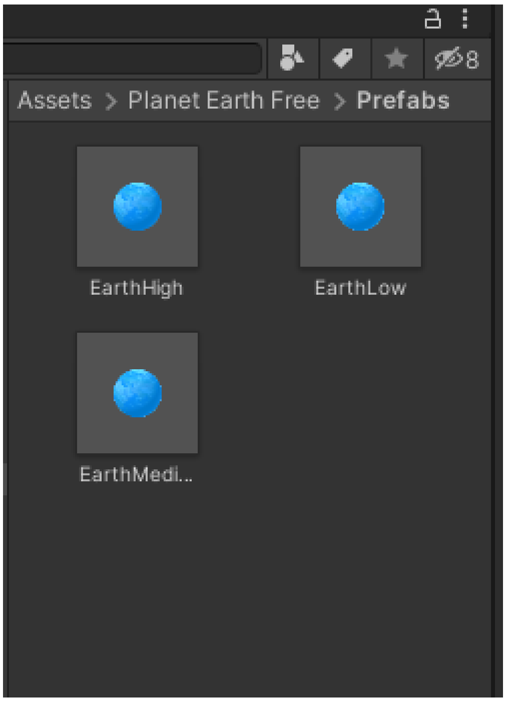

Figure 21. Prefabs selection

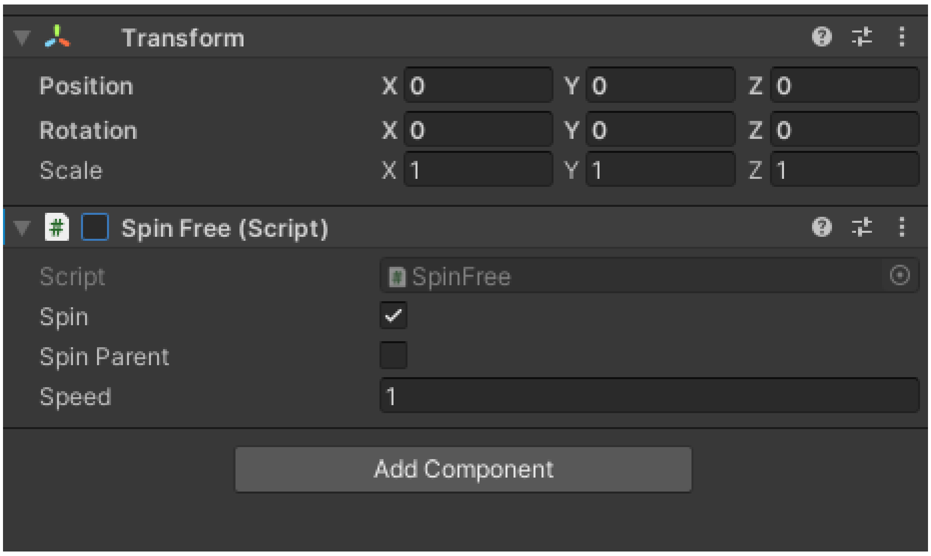

Figure 22. Uncheck the rotation script

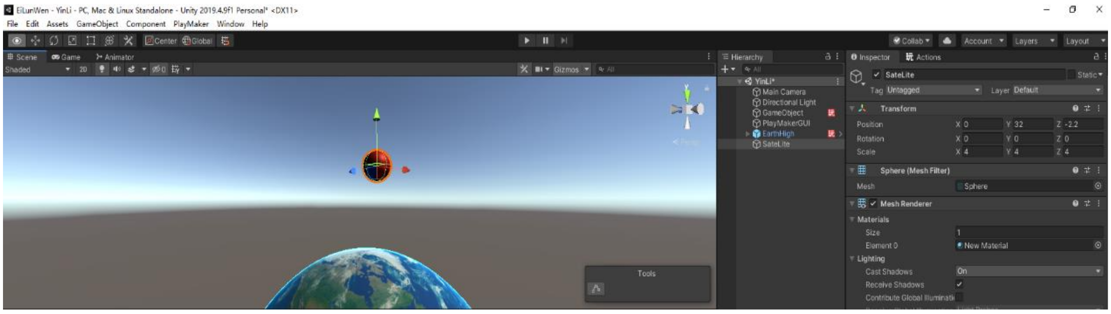

Figure 23. StateLite settings

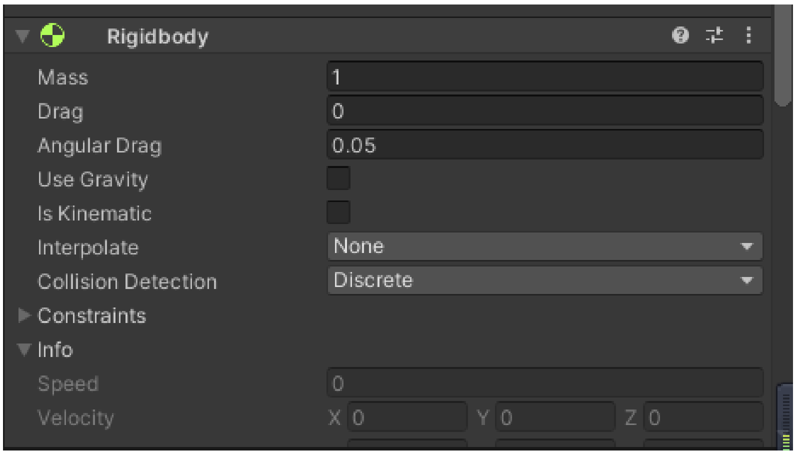

Figure 24. The rigid body assembly unchecks the gravity setting

The Earth in the scene is visually programmed to simulate the phenomenon of Earth tilt rotation.Click on the EarthHigh in the scene, right-add State in the Playmaker editor, select Add Torque in the Action Browser, and add it under the State.The Action indicates giving a moment to the target object.The settings are as follows:

Game Object, choosing Use Owner, indicates that the moment is acting on its own.

Assigning to 10 to X and Y to 20 indicates assigning a force to both the horizontal and vertical directions.

With the above setting (as shown in FIG. 25), the physical phenomenon of earth rotation can be shown.

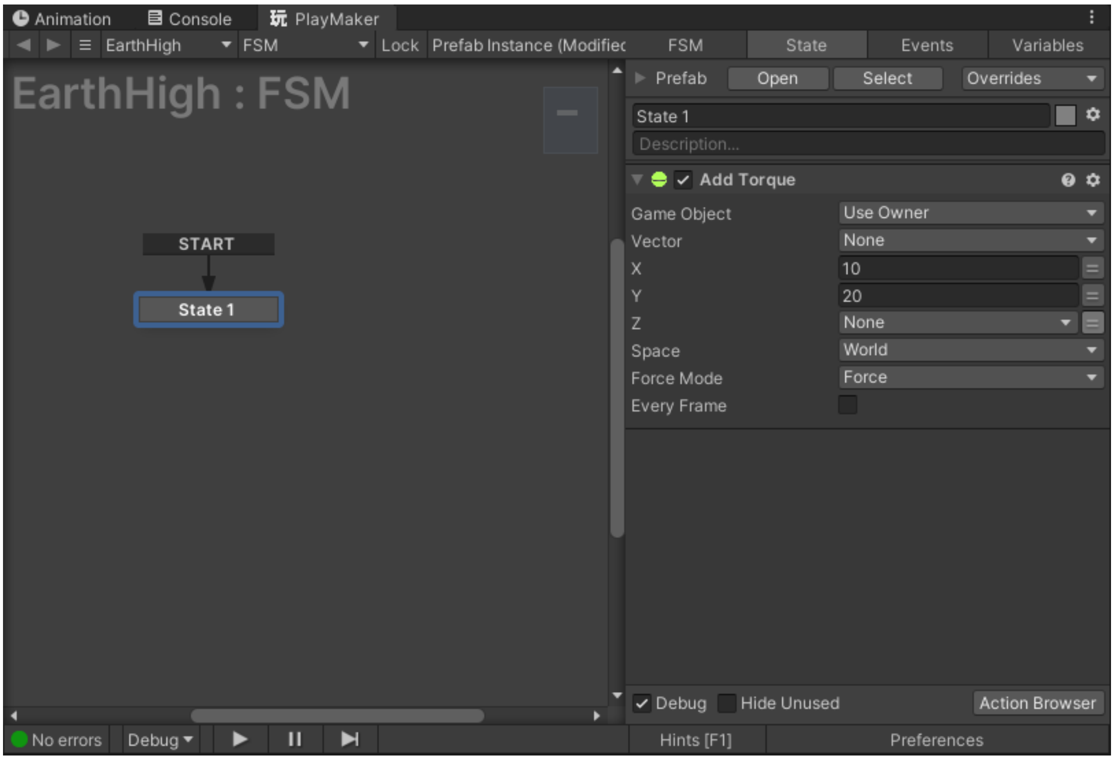

Figure 25. Add Torque settings

Select the Game Object object in the scene, and add State.

Three variables were first set, respectively, the Float-type variable F, representing the force driving the StateLite.The Float-type variable H, which represents the initial height of the StateLite.Type Vector3 variable P, used to record the location of the StateLite in real-time.

About the Settings for the State1:

① adds GUI Vertical Slide, set as follows:

Float Variable: Set to variable H (indicating that the vertical slider controls the StateLite height);

The Top Value and Bottom Value were set to 70 and 23, respectively;

The slider position is set to Left: 0.1, Top: 0.15, Widen: 0.1, Height: 0.6; (as shown in Figure 26)

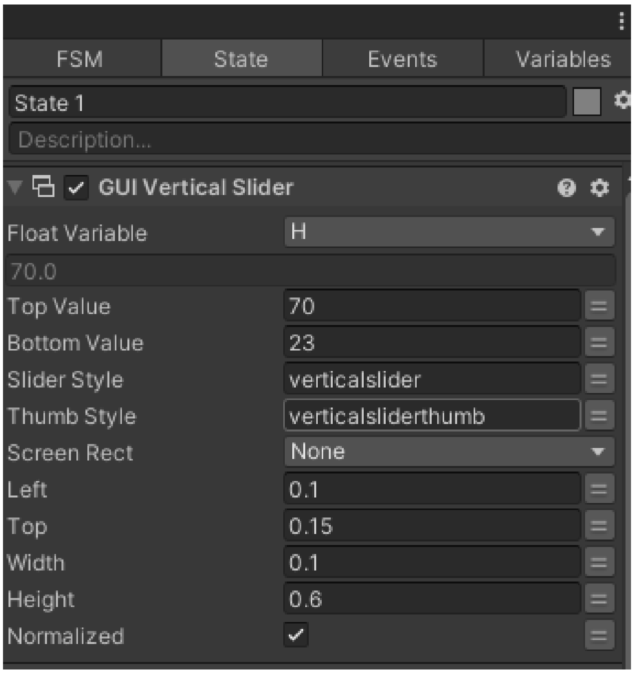

Figure 26. GUI Vertical Slide

② adds GUI Horizontal Slider, set as follows:

Float Variable: Set to variable F (indicating the power of the horizontal slider controlling the StateLite horizontal direction);

The Left Value and Right Value are 0 and 1,000, respectively;

The slider position is set to Left: 0.25, Top: 0.9, Widen: 0.5, and Height: 1 (as shown in Figure 27).

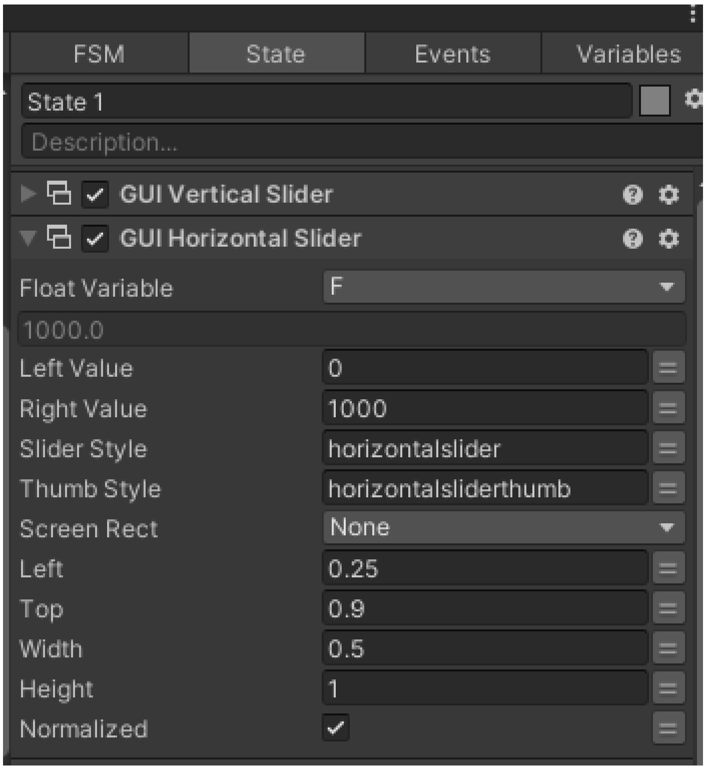

Figure 27. GUI Horizontal Slider settings

③ adds Set Vector3 XYZ, set as follows:

The Vector3 Variable is set to the variable P;

The Y is set to the variable H;

Check the Every Frame (indicating that each frame is calling the above data) (as shown in Figure 28).

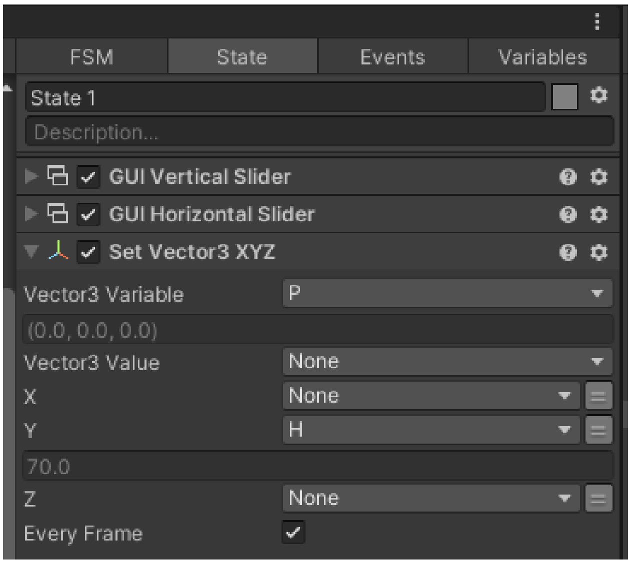

Figure 28. Set Vector3 XYZ settings

④ adds Set Position, set as follows:
Game Object: Select Specify Game Object and select SateLlite;
Vector: Set to variable P; check Every Frame (as shown in Figure 29).

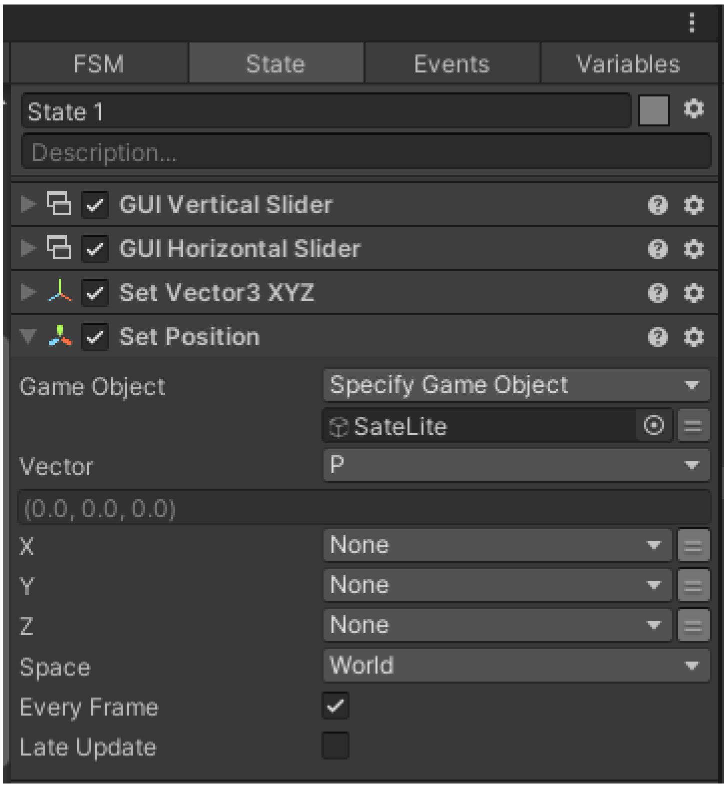

Figure 29. SetPosition

⑤ adds Get Key Down, set as follows:
Key is set to F (indicating triggering the practice when the F key is pressed) (as shown in Figure 30);

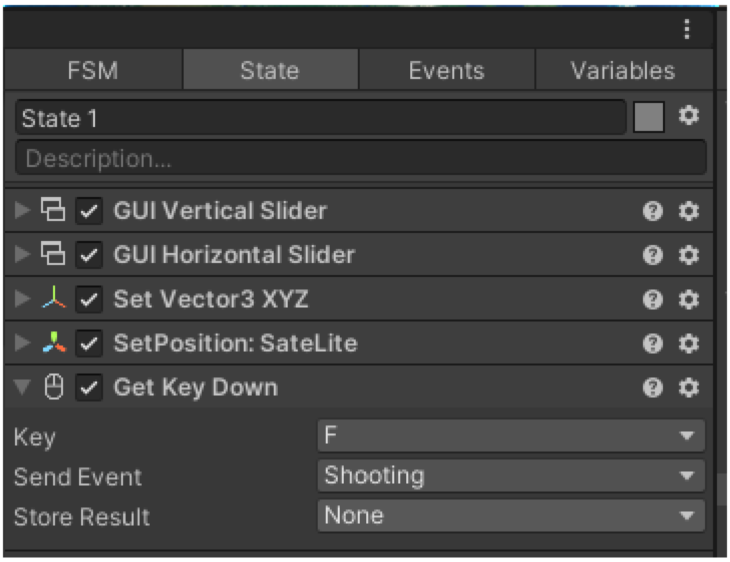

Figure 30. GetKeyDown

The Send Event is set to launch, select the Events window under the Playmaker edit window, add new events to the Events window, and name the Event "Shooting" (as shown in Figure 31).

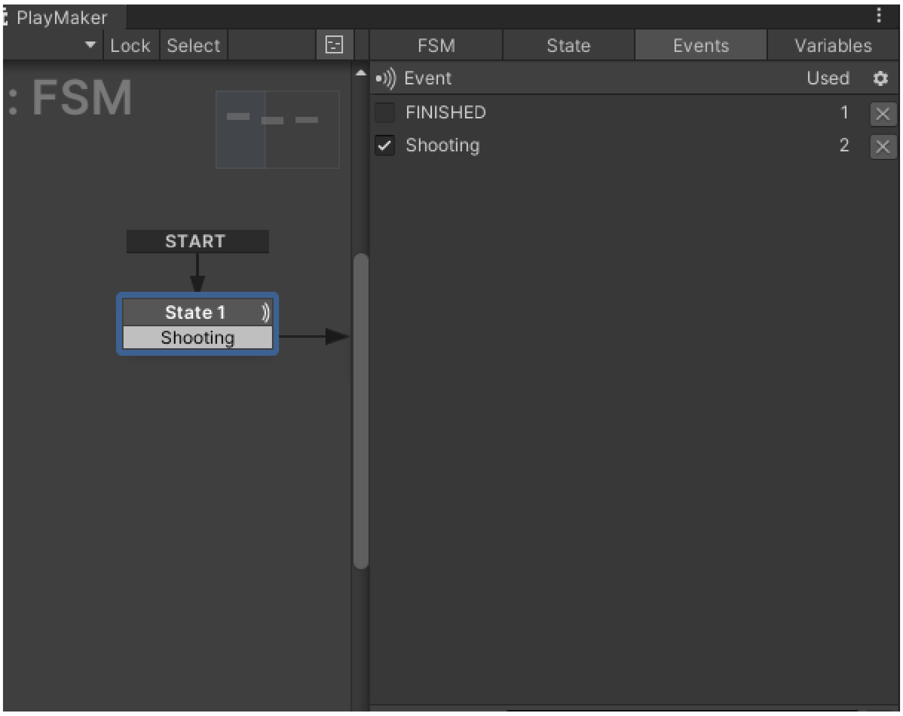

Figure 31. The "Shooting" Event settings

⑥ Right-key State1, select Add Transition, and select an Event named Shooting, just added.

About the Settings for the State2:

Create a new State2, add a Add Force, and set it up as follows:

①Game Object: Select Specify Game Object, select SateLlite; (meaning that the force is added to the SateLlite)

②At Position: Select variable P, X: Select variable F.

The ③ connects the Shooting event to the State2, right-click the State2, select the Add Transition, select the FINISHED option, and add the FINISHED event (as shown in Figure 32).

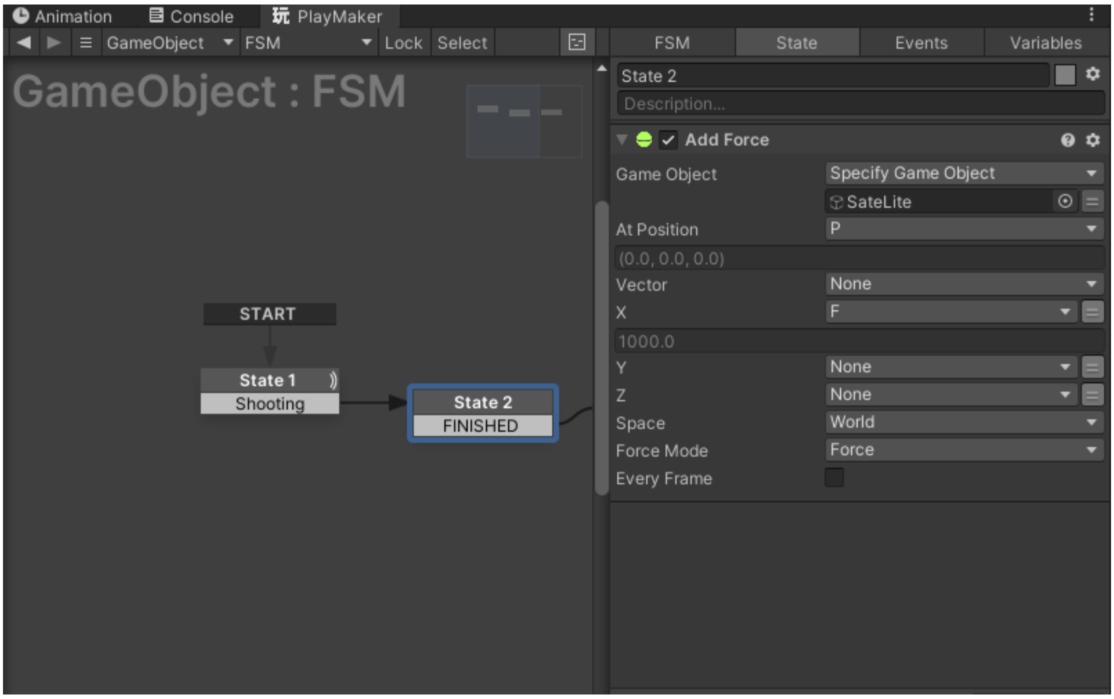

Figure 32. A d d, F o r c e settings

About the Settings for the State3:

Add Add Explosion Force, since there is no Action about gravity in Playmaker and change the direction of the force to a negative value.

①Game Object: Select Specify Game Object and select SateLlite;

② Force: Select the-10, check the Every Frame (as shown in Figure 33),

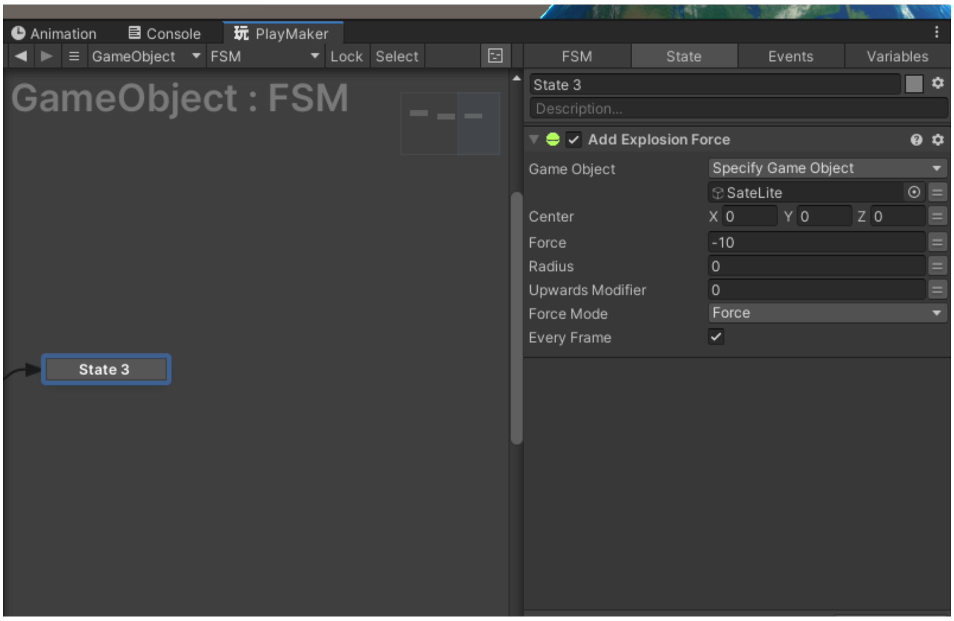

Figure 33. Add Explosion Force settings

These are all the programming settings of this experiment, the specific programming structure (as shown in Figure 34).

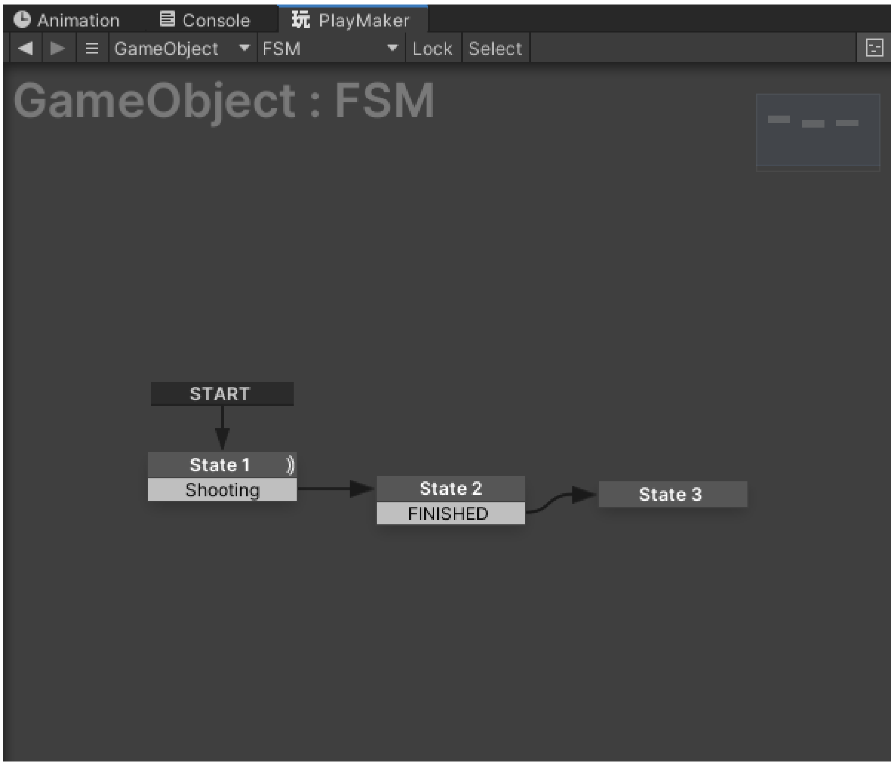

Figure 34. Specific programming structure

5. Summary

Through the virtual experiment design, can intuitive show the physical phenomenon, and has a certain interaction, can make students more clear understanding of the physical knowledge, not only that, the implementation of the virtual experiment using visual programming, in the process of programming without a line of code, greatly reduce the programming difficulty, can add fast design the prototype of the experiment. The experimental design is in the prototype stage, and some details and 3 D resources can be further optimized. With Unity's continuous development and progress of HDRP (HD rendering pipeline), experimental design can achieve better and realistic results to be achieved through HDRP. This is also one of the directions of the continuous progress of virtual experiments

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