A Control Mechanism of The Physical Simulation Experiment based on Game Engine

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Abstract—**Experiment is the basis of physics science, core of it is the control of the process. With the development of technology of game engine, the simulation of physical experiment based on game engine achieves good effects [1]. This paper proposes a new control mechanism based on trigger mechanism for the physical simulation experiments that will be available for the students to control the experiments in process, space, time and events.**

Keywords-physical simulation experiment; control; trigger mechanism; game engine.

I. INTRODUCTION

Physics is a subject of natural sciences based on experiments which do research in a large number of physical facts and phenomenon[2]. The experiments are the source of the knowledge of physics. Neither the building of physical concepts, nor the discovery of physical laws can be separated form the experiment. The experiment is the base path of learning physical knowledge and building the capacity of observation, operation and physical thinking. Experiment is an important department of physics teaching.

With the social process and development, game is accepted as an important means of fun and education by the people. The technology of three-dimensional (3D) game engine matures at the same time. There are many advantages in using 3D game engine in the physics teaching. Firstly, the technology of simulation based on physical operation is great in improving the interaction and reality of virtual scene. Secondly, it will bring real feeling to the students to help them learn and explore actively by allowing them to manipulate virtual objects in virtual environments by input device and get the feedback made by virtual objects in the environment.

The new perspective of course advocates building the student's capacity of self-exploration and solving problems, and training scientific quality. Inquiring teaching as a new form advocated by the recent reform of education, advocates that the students inquire and solve the problems by themselves. In the physics teaching, students can learn, build their comprehensive capacity and train their scientific quality in the way of inquiry learning in the experiment's process[3]. This paper proposes a new control mechanism for the physical simulation experiment based on game engine that will be suitable for the inquiring learning and convenient for controlling the experiments.

II. A PLATFORM OF THE PHYSICAL SIMULATION EXPERIMENT BASED ON GAME ENGINE

A. The experiments in physics teaching

The implementation of quality education in physics teaching is training the talent who has high scientific quality. That's performances in the comprehensive capacity whose key is the education of scientific methods. The methods are the means of researching the objective laws in nature. Scientific system of physics is composed of the physical concepts and laws, these concepts and laws are built on the basis of the experiments. There are many variables impact material's movement, we should simplify the experiment's scenario by controlling the variables and studying the phenomenon beginning with the simple, to make people aware of the objective laws gradually. In essence, the experiment is a process to create an environment and controlling the process of material movement artificially and also an operation excluded interference and highlighted the main factors in an ideal environment. Therefore, the core of experiment is "control", which shows the methods of physics researching and the process of inquiring learning: the students explore the coordination of the relationship between knowledge and capacity, be trained in the scientific method and thinking in the inquiring experiments[3].

B. A platform of the physical simulation experiment based on game engine

The 3D game engine bears these jobs: scene construction, object operation, scene rendering, event handler, collision detection and so on[4]. The technology of 3D game engine has matured, and it is used in a lot of fields in addition to game, for example, education game is researched hotly nowadays[5]. The physics simulation experiment in the framework of 3D game engine can provide the function of visualization display and realistic virtual 3D scene of experiment for students. In addition, that has great interactive performance, controllability, reusability and scalability, provides the way of controlling experiment for students.

The platform of the physical simulation experiment, bases on the 3D virtual scene, creates the environment of physical question, promotes the students to get the point of experiment, control the process of experiment, study in inquiring

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learning[6]. The students choose the knowledge point firstly after entering the platform. Then they analyze the issue, give the relevant scientific proposition. After that, they enter the 3D virtual scene, get into the experimental process and control the process using the method provided by the platform. They collect the stats of experiment in process, answer the scientific questions based on the factual evidence. The framework of the platform, as shown in Figure 1.

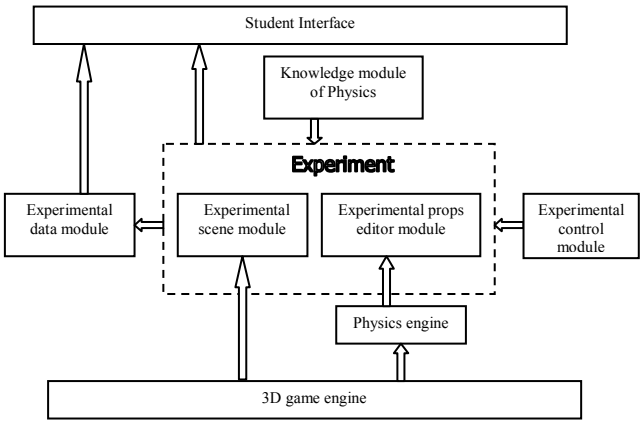

Figure 1. Framwork of the platform

3D game engine: This paper chooses the Torque game engine (TGE) of GarageGame Company as development platform. TGE is an object-oriented, relative fully functional game engine, it has many features, such as the bottom shading technology based on OpenGL and DirectX, the rendering engine, the towed GUI creating, the built-in world editor, the C language-style scripting language and so on[7].

Physics engine: This paper chooses the Open Dynamic Engine (ODE), ODE is a rigid body dynamics simulation library, used extensively in the mechanical simulation project and 3D games. It provides six designed joint constraints, integrates the open source collision detection library Opcode, supports for collision detection, provides an interface called and facilitates integrated application and secondary development. The virtual reality environment based on the methods of physical simulation, greatly improves the authenticity and interaction, makes it possible to simulate the complex physical phenomena.

Experimental control module: the interactive mode based logic control module in TGE, provides the method of controlling the experiment process which contains the operations of controlling. That is the core of the experiment in platform, it make experiments more controllable and easy for students to control the process.

Physics knowledge module: one collection of scientific physics knowledge, every knowledge point contains the relevant physics law and experimental contents. Students can choose knowledge point what they wanted to learn, give the relevant scientific proposition when entering the platform.

Experiment scene module: one collection of experimental scenes in TGE. The visual 3D scene editor provided by TGE can edit the scene easily, save the scene and edit secondly. After chosen knowledge point, the students analyze the issue and come up with a solution, then enter the prepared corresponding experimental scenario, prepare for explore of the proposition put forward.

Experimental props editor module: one tool of virtual experimental props based on TGE and ODE. Students can edit the physical properties of the needed props. It is convenient for the students to control the process of the experiment.

Experimental data module: it shows the experimental data in the interface of TGE, provides the students with data they needed to help them collate information and explain problems easily.

III. THE CONTROL MODULE BASED ON TRIGGER MECHANISM IN PLATFORM

The core of physics experiment is “control”, the control module is an important part of the platform of physical simulation experiment, that provides the methods for students to discovery and solute in experiments. The students can control the process of experiment easily. The part of logic control in game engine bears to add the objective laws and game plot to the virtual world such as collision detection, reverse movement, gravity, inertia, velocity and artificial intelligence (AI). Based on the logic control module in TGE, we design a control mechanism based on trigger mechanism. Trigger mechanism is an event-driven constraint, when the operations of users or some factors achieve the conditions, the related operation will be triggered. The control based on trigger mechanism can make the students play a dominant role in the experiments, easily control the process.

User-trigger: The students can suspend or start the virtual experiment by push the pause/start button in the interface. When pause in the middle, the system records all the objects’ status in scene and save it into a file, then, keep all objects immobile until users start the experiment. When the experiment starts again, the system recovers all the objects’ movement according to the file saved below. User-trigger makes the virtual experiment be controllable. It also provides the students with a path of observation and data record.

Area-trigger: TGE provides area trigger for game logic[8]. Area-trigger is an object that can be defined in the 3D scene with space. When some objects enter the trigger’s area, trigger will detect that and call some related operations. The students can place triggers in the scene freely. Area-trigger helps us to grasp the elements of the experiment in 3D space.

Time-trigger: The students can set up a countdown in the middle of the experiment process by using the time function provided by TGE. When completion of the countdown, the trigger will call some related operations. Time-trigger makes the students be able to control the experiment process accurately in time.

Detection-trigger: TGE provides the function of collision detection. That is a callback function, when some objects collide, the object will call the function automatically, so, we can get the moment of collision. We also can detect the moments of incident happens by design a state machine by using TGE script. For example, if we want to suspend the

experiment when one object meets certain conditions, then we check the object's status in each cycle to meet the conditions, if meets, the experiment will pause. Detection-trigger makes the students can get the very moment of the key point in the middle of the experiment, and get related information about the point.

The control module based on trigger mechanism in platform can control experiments accurately and effectively in process, space, time, and event detection, provides support for the controlling of experiment in the platform.

IV. THE CONTROL OF THE CONSERVATION OF MOMENTUM SIMULATION EXPERIMENT

We use the simulation environment to demonstrate the conservation of momentum experiment. The experiment is complex and expensive to be demonstrated in traditional teaching. In traditional, the process is hard to control, the effect is always unsatisfactory, the data is hard to collect and the data's accuracy is poor.

The process of conservation of momentum experiment: two cubes with different volume and mass stay in smooth surface with no friction statically, one of the cubes with mass m1 begins to move in velocity of v1, it collides with the other cube, then both of the two move in velocity of v2 in the direction of v1. Though the experimental data, the students can authenticate the theorem of conservation of momentum m1 * v1 = (m1 + m 2) * v2. In this experiment, we need to get the cubes' velocity before and after collision, and the moment of the collision. In order to achieve the purpose, we place area triggers in front and back of the cube m 2 and set collision detection of cube m1. When the cube m1 enters the triggers or collides with m2, system will suspend the experiment, and then we can get the velocity of the cubes.

We create two cubes in the virtual scene with ID 2748 and 2910 through mission inspector. Then, we define the physical properties for the cubes in the properties editor and apply to save it. For controlling the process, we place area triggers in front and back of cube 2748 and set collision detection in scripts. As shown in Figure 2.

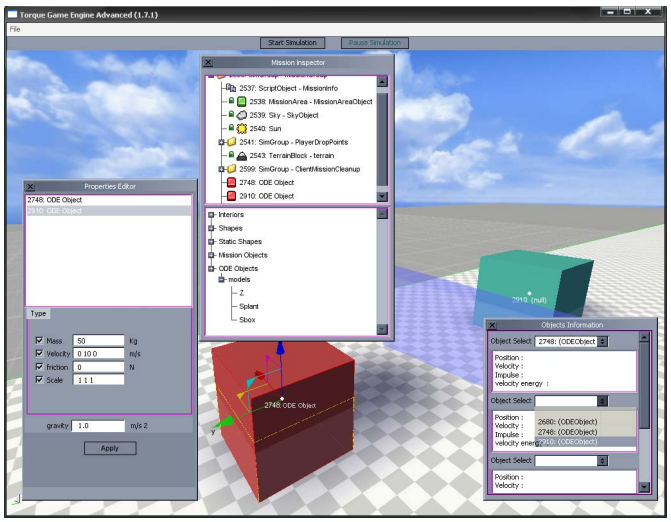

Figure 2. The scene of the conservation of movementum experiment

After turn off the unneeded panels, we click the button named start simulation in the top of interface to simulation the experiment. At the same time, the panel of objects information shows the real-time information of the object selected, including position, velocity, impulse and energy. At the very moment of the collision, the experiment will be pause, as shown in Figure 3.

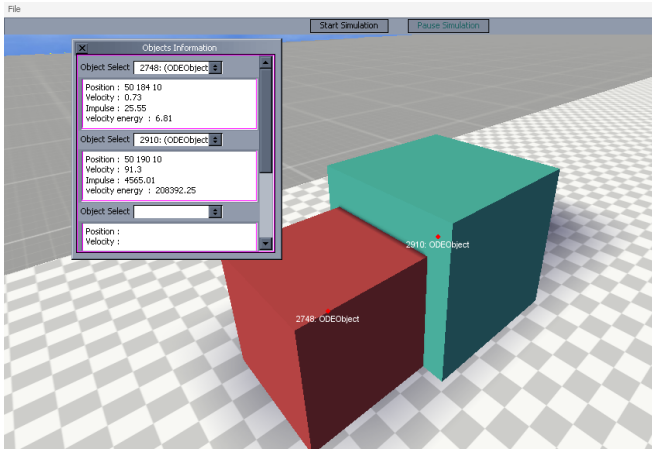

Figure 3. Pause when collides

V. CONCLUSION

The control mechanism based on trigger mechanism of the physical simulation experiments is available for the students to control the experiments in process, space, time and events. In the virtual visual convenient experimental environment, the students can control the process accurately and effectively in experiments to build their comprehensive capacity and improve the quality of science. There are two aspects of the control mechanism to be improved. Firstly, the function of it is not comprehensive, we will instantiate more of experiments. Secondly, the operation of control is a little complex, we will make it modular to be convenient.

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