Interactive Object and Collision Detection Algorithm Implementation on a Virtual Museum based on Croquet

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Abstract

3D technology has significantly been improved during the last few years, especially in OpenGL library which enable programmers to create 3D shapes easily in some applications. This technology can be applied for Virtual Reality. In order to implement real elements into virtual simulation, some features to be considered are graphic quality, sound quality, user ability to interact with applications, controls, and algorithms to support virtual simulation, such as collision detection.

In this work croquet is used to create an interactive virtual museum. In this virtual museum, users can interact with certain objects, such as museum door, manuscript, and lift. Our virtual museum is enhanced with animated object. We also added collision detection mechanism to prevent avatar from penetrating objects.

This application was tested by ten users. They appreciated the overall quality of the museum, and satisfied with the interaction of the simulated objects, as well as with the result of the collision detection.

Keyword – Croquet, Collision Detection, Virtual Museum, Virtual Reality.

1. Introduction

3D simulation has touched many aspect of human lives, due to its esthetic characteristics and its capability to mirror the real world. Virtual Reality a kind of an advanced 3D. An example of the virtual Reality application is virtual museum in which a user can interact with other users in the museum sphere. They also can touch the museum’s artifact virtually. Another advantage of virtual museum is that the museum’s visitors can see the museum’s collection from the Internet.

Croquet is one of many application that can be used to create virtual reality. However Croquet have some weaknesses, such as no default feature for collision detection, causing the user to emerge the walls when walks through it.

Virtual museum in this work is presented using interactive whiteboard that has a special whiteboard marker as the input device. The objective of this project is to make virtual museum application which enable virtual interaction with object and implement collision detection on every walls.

In this paper we present our work on creating a virtual reality application to create a mirror image of a museum. We implement a collision detection mechanism so that users can walk freely without possibility to emerge through the virtual walls, and implement interactive object.

2. Virtual Reality

Virtual Reality is a sphere from computer simulation. 3D graphics and a stereo sound is required to improve its realness. Users may use standard computer input devices such as keyboard or mouse, or special devices such as wired glove, polhemus boom arm, and omnidirectional treadmill. It is predicted that in the future VR will greatly influence human lives.

One of the most famous virtual reality application is Second Life, which is a virtual world based on Internet network developed by Linden Lab. To take part in this application, a user must buy an island and own an client program known as resident. Each resident can interact through an avatar, adventuring the world, participate on quests in group or individually, create and trade goods and other kind of services.

In virtual museums the placement of the museum collection such as paintings, photos, carved object, ceramics, antique materials, etc, can be conducted virtually [1, 2]. One of the virtual museum is Getty museum. The program of Getty Art History Information is aimed at providing multimedia education and stored arts creation and a lot of information from six museums and seven universities [21, 22].
3. Supporting Technology

3.1. OpenGL

OpenGL is a standard library to write computer graphic application both 2D and 3D [3, 16]. OpenGL is developed by Silicon Graphics and compete with Direct3D on Microsoft Windows platform. It is used on virtual reality, scientific visualization, flight visualization, and video game.

OpenGL specification is produced by OpenGL Architecture Review Board (ARB), in which the members include many 3D hardware developer companies. OpenGL has been used to overcome interface complexity using other 3D accelerators by giving programmer an API and limit the difference of many hardwares. OpenGL also supports basic functions such as graphics pipeline, z-buffering, texture mapping, and alpha blending.

OpenGL API was started from SGI initiative to develop 2D and 3D applications. Previously, hardware vendors have their own graphic library and compatibility is the main issues.

3.2. Croquet

Croquet is an application which support collaboration and resource sharing from many users with 2D and 3D simulation [8]. It enables us to change and to have a virtual world. Croquet could be used to create collaborative data visualization, virtual learning and problem solving environment, 3D wikis, or online gaming. It uses OpenGL engine with all existing objects which has full access to OpenGL library.

In Croquet, Space is a container from many object types, including avatar users. Portal is connector between spaces. Portal concept could be analogized as door on real world. The difference is the that the two spaces connected by a portal do not have to be physically connected, whereas two spaces connected by a door on a real world have to be physically closed. A mirror is a portal which is connected with the same space.

Croquet is based on a Squeak, an open-source platform which implements Smalltalk. Smalltalk language is one of the first object-oriented language in the world [6, 8, 9, 10].

3.3. Interactive Whiteboard

Interactive whiteboard looks like a standard whiteboard, but it enables users to interact directly with the display unit using a special pointer [22]. The display is projected to a whiteboard using video projector. This interactive whiteboard could be connected with a computer through a wire or bluetooth using a special driver. This driver replaces the contact or position of the special pen into the mouse right button function.

3.4. Virtual Network Computing

Virtual Network Computing (VNC) is used in this work to access other computer on the viewer’s computer as well as to optimize the use of computer resources. VNC is a desktop system which uses Remote FrameBuffer (RFB) protocol to control other computer automatically [5]. VNC transmits event from the keyboard and the mouse of a computer to other computer, conveying update from the graphic screen to opposite direction, through network.

VNC system consists of a client, a server, and a communication protocol. VNC server is a program in a machine which divided appearance on that server.

4. Virtual Museum Implementation

4.1. Virtual Museum Structure

In this work, the virtual museum has been designed through some steps. The first step is to decide the museum's sketch and objects to be placed inside it. The second step is to generate detailed design. The third step is to program Croquet using SmallTalk language. Figure 1 shows the virtual museum map.

This virtual museum consists of two floors. The first floor is filled with objects which could interact with other animated users and objects. The second floor is filled with many types of famous paintings from different time. Objects which are placed inside this museum are an analog clock, a lift with an automatic door, museum's door which could be opened or closed, manuscript which could be opened back and forth, portal to previous scripts, many types of sculptures and paintings. Figure 2 and 3 show the UML diagrams of the system.

4.2. Virtual museum design integration into Croquet
In this virtual museum, users could explore virtual world, interact with wall, interact with lift, interact with manuscript, interact with museum’s door, enter into the portal, and see many objects.

Method initialize is the main method in this application. Class for this method is a factor from Croquet Harness, which is a class filled with minimum system to make a space. In this part TSpace object was made with name space, which is comparable with empty space. Subsequently we created the floor and space lightning. The museum building’s was drawn using primitive objects which are placed inside Croquet. This will accelerate loading process rather than if we import 3D type file with .ase format [11, 12, 13].

Analog clock which is placed inside the museum was illustrated by combining three basic form. The first one is a rectangular form with clock background texture. The second and third forms are cylinder form with different maximum and minimum interval to illustrate the long and short clock’s hand. turnClock method is used to move the clock.

The museum’s door was made and controlled by TPintuMuseum class. This door could be opened and closed by a left button mouse click at the door object. This class is the factor from class TFrame and has pointerDown method which can be moved when users perform some action to this door. In this method there is an open variable which could be used to decide the position of the museum’s door, whether it is open or closed. Manuscript is an object formed like a book which could be turned back and forth.

There are two types of manuscript. The first manuscript would turn over by pages, whereas the second manuscript would turn over by the page’s degree. All of the manuscript’s pages are illustrated using primitive object which forms like cube. Each page was given a number texture which indicate page number. Manuscript was controlled by TManuskrip class. The variable clickOpen value will decide the position and the angle for each page. Combination from those attributes would make a book which is opened on certain page.

Lift is an object with lift form which is used by avatar to move from first floor to second floor. This object is controlled by two class, which is TLiftMuseum and TLangitLift. TLiftMuseum controls the work of the museum’s door in the first floor and the second floor, and TLangitLift controls lift movement to the first floor or second floor.

4.3 Collision detection

Some related publications show that collision prevention is an important issue in 3D graphics [14, 15, 17, 18, 19, 20]. In our work, we define the collision detection algorithm in two steps. The first step is to detect whether avatar collides with wall. Then, if collision happen, it will give response by backing avatar to the nearest position to the wall but not piled it with wall.

The TAvatarUser class, that controls the movement and other attributes from avatar. This algorithm works by taking the avatar first position when users click the right mouse right button, and would do the test when users release mouse right button.

To test whether avatar collides with wall, virtualWall method is used. In this method, the cube that couldn't be seen physically was made and
could be made analog with a border cube which blocks avatar movement.

The type of avatar movement, that is whether it move to the southeast, to south, and so on could be determined by comparing avatar position before and after it moves horizontally or vertically. This kind of movement was used as a suggestion for CollisionDetect method.

CollisionDetect is a function which gives true value if avatar collides with wall. This function work by comparing each avatar position element before and after it moves with the position where the collision happened. If the collision position exists between before and after position at one straight line, then the collision happened. Information of the collision of the avatar and the detection of the four sides of the wall is detected by the function called CollisionDetect.

5. Result Analysis

5.1. Testing

The import process of a 3D ASE formatted file consumes a lot of CPU resources and slows down the loading process. Figure 5 and 6 shows the avatar in this virtual museum. Interaction with the museum objects is done by the clicks of left button of the mouse at the object. The test at those objects is conducted by checking the animation which has been done by an object when users interact with that object.

The collision detection algorithm test is done by bumping avatar to the wall. To know whether avatar collides with wall, transcript is used, that is a window at Croquet to show a test information when collision happened. Then the text appears. Subsequently avatar will look like it will pierce the wall. However it then moves back to the nearest position to the wall.

Collision detection algorithm at this application has a weakness as the avatar’s first position of data taking is done when the users click the right button of mouse. Collision detection process and its response would be run only when the users release that button. If users move the avatar by holding the right button of the mouse, system would seems to be slow to prevent collision.

VNC connection is used to connect the system with a manuscript which has been implemented using Grid computation based on Globus and Java language. The computer in which the application is moved acts as a viewer, whereas computer with the old manuscript acts as server. System which is connected with that VNC uses the interconnection from some computer with Globus Toolkit application. The Server controls and manipulate the object based on the client request.

5.2. Test by ten users

A questioner has been distributed to 10 respondent to test and evaluate the application. The results are shown in Figure 7, 8, 9 and 10.

The result of the survey shows that in the average, users are not familiar with the language used in the application. SmallTalk language is not commonly used compared with other object-oriented language like Java.
is natural considering that the graphic quality from Croquet application with 3D graphic are not as good as the image from films and video game. The result of the evaluation of the museum objects shows that users were satisfied enough with the presented object. Most users know what collision detection means and considered that the implementation of collision detection in this application is correct. The work of collision detection is evaluated as moderate and the users expect it to be smoother.

5.3. Future development

A better collision prediction algorithm could be planned to prevent the collision, especially to alleviate the backward movement of the avatar. The interactive object could be developed in a more flexible way to give more options to the users to do multiple actions to an object.

6. Conclusion

In the future, the collision detection algorithm could be used to make various applications using Croquet, such as war simulation, fighter plane simulation, and other games. The existent of collision detection will support better applications and enhanced the look and feel of the application.

7. References