An Application of Virtual Reality in E-learning based LEGO-Like Brick Assembling

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Abstract

E-learning is a new teaching model nowadays, and Virtual Reality (VR) technology is reported that the use of virtual reality as an education tool can increase student interests, understanding, and creative learning because of encouraging students to learn by exploring and interacting with the information on the virtual environment. Besides that, LEGOs have long been the favorite of many children. LEGOs provide a mechanism to understand and do for many concepts from spatial relationships to robotics platforms. In this paper, we present a virtual reality application based on the assembly of LEGO-Like bricks to increase math and science learning by improving spatial thinking. It not only encourages students to pursue careers in science, technology, engineering, or mathematics but also enhances learners' ability to analyze and solve problems. The application is built by Processing 2.0 as the easier programming language which is a top-down approach to build the 3D interactive program.

1. Introduction

Nowadays, the rapid development of computer and network technology has been given rise to transform in human social life and modes of thinking. Following this trend, E-learning platform in combination with technologies such as information, multimedia alters the traditional learning style and learning environment. By breaking through the limitation of traditional education in time and space, learners can not only study at anytime and anyplace but also they can do cooperative study through the platform. It encourages students more proactive about the Modern Learning Environments (MLE) and stimulates the creativity and imagination of them.

VR technology can create a 3D virtual environment in a computer by the use of computer graphic system in combination with various display devices. The application of 3D real-time VR in education platform provides the more useful, flexible, and virtual learning environment. Therefore, it has been applied widely in education, especially the science experiments. Students can interact with the virtual environment via input devices, such as a mouse, keyboard.

Lego is a line of plastic construction toys that are manufactured by The Lego Group that began producing the interlocking toy bricks in 1949. Lego pieces can be assembled and connected in many ways, to construct objects such as vehicles, buildings, animals and working robots. Therefore, LEGO has been used in many classes to teach a wide variety of concepts from spatial relationship to embedded computer control of mobile robotics platforms. It not only improves students' knowledge of science, mathematics, robotics, computer programming but also cultivates tenacity, skepticism, curiosity, and imagination of them. Furthermore, learning is greatly improved with "hands-on" activities. LEGOs provide an excellent tool to combine both computer-based education and hands-on learning. However, the price of a LEGO product is quite high and new models are produced continuously. Therefore, the cost of owning the LEGO products of classroom practices will be quite high.

Based on the above concepts, we propose a virtual reality program that allows users to build models using virtual LEGO-Like bricks. Students can produce their artifacts which can be shared with others and cause reflection in the process; they are more likely to create new ideas. Our application can help students improve their learning achievements, and the related subjects are mostly concentrated in mathematics and physics, exploring the knowledge of angles, ratios, graph construction and interpretation and so on. The paper's organization is as follows. In section two, we review some of the modern applications for LEGOs assembling. In chapter three, the implementation of our application is presented; emphasis on the more intuitive gameplay is given. Section four offers the experimental results with our application, and finally, section five, concludes the paper and provides a view of the future work for the program.

2. Related works

Nowadays, there are some applications created using the LEGO modeling concept. The LDraw [13] (1995) is a system of free software tools for modeling LEGO creations in 3D on a computer. The LDraw parts library consists of many of the original parts modeled by James Jessiman. Since then, a variety of programs have been written that use the LDraw parts library, and file format as construction materials, such as LeoCad and LEGO Digital Designer.

LeoCad [14] is a CAD program for creating virtual models. It has an easy to use interface and currently include over 6000 different pieces. Users can add pieces to a model, move and rotate pieces, create a model with multiple steps and change the camera position. However, movement of parts can be only performed using the keyboard. The arrow keys move along 2 of the axes while PageUp and Page Down move along the third.

In 2004, the LEGO Group introduced a free virtual reality program named LEGO Digital Designer [15], or LDD that

allows users to build models using virtual LEGO bricks. The program features a palette of bricks and pieces of different colors that can be used to create any model imaginable. In spite of this, this application is suitable only for some enthusiastic LEGO users who can use a computer competently and have knowledge of the 3D solid geometry. Therefore, the beginner will hardly be able to use this program.

In this paper, we propose a virtual reality simulation that has a more intuitive way. We present a new approach for assembling LEGO-Like bricks based checking collision between the mouse cursor and the box collider of the brick or the plane.

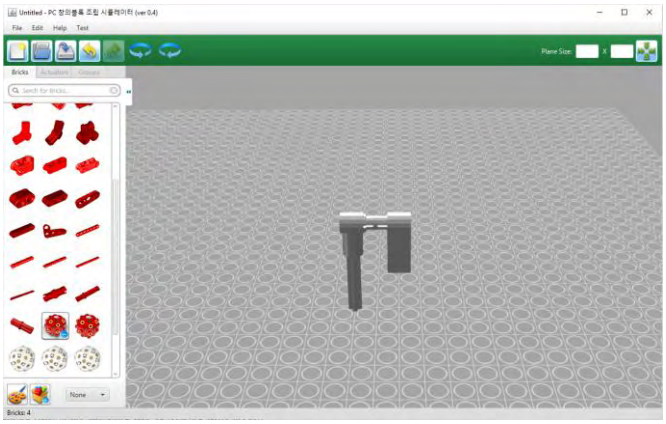
Wichita State University is actively using LEGOs to encourage science math engineering and technology [7]. This participative demonstration has been used in middle school, high school, and college classes. The purpose is to develop technologically astute and competent teachers who are capable of integrating technology into their curriculum to improve the teaching and learning of their students. Based on LEGO Mindstorms kits, the Build IT project [6] exposes students to science, mathematics, and engineering concepts such as buoyancy, momentum, density, etc. To establish a connection between building with LEGOs and improving math scores, Tanner Clark [8] created a project titled “Build Your LEGOs, Build Your Brain!” Through the results of the initial experiment, boys in the experimental group from the proficient/advanced class outperformed the control group from the same class.

There have been several types of research on collaborative VR environments for education and training. For instance, “The Virtual Maze” [12] is a game to promote social interaction between children. The Virtual Maze, a technology augmented-space in which children at primary school age can develop collaborative skills while playing. Young-Suk Shin [1] presents a virtual environment (VE) for science education using virtual reality simulation. Students can select the learning level in the exploring step of learning cycle model: regular, advanced and remedial courses according to the degree of their comprehending or interest about the learning topic. F. Yang [3] represents the essential role of VR and e-learning through a virtual physics experiment built by Java3D. This virtual learning environment provides a new study method for students to understand of certain events which have proven inappropriate and challenging in traditional education.

In this paper, we present a virtual reality environment to encourage students to study math and science. When students build some models which can be shared with others, it makes the creation of the model becomes more attractive besides improving social interaction skills. Therefore, they are more likely to create new ideas.

3. Implementation of the application

In this section, we describe the implementation of our program, an interactive game-based virtual environment for students which can be realized by technologies such as OpenGL, Direct3D, VRML and Processing 2.0 programming language. It is quite difficult for the beginner to grasp the OpenGL technology because it uses C/C++ programming language to create complex 3D graphics. Direct3D technology developed by Microsoft Company only works on Windows platform. VRML (Virtual Reality Modeling Language) is a simple programming language for beginners to grasp in a short time. However, VRML didn’t be applied widely for the following reasons. First, different Web browser needs install different plug-in when it runs the virtual environment modeled by VRML. Second, some complex functions (collision detection) can’t be implemented by VRML technology. Processing 2.0 is a flexible software sketchbook and a language for learning how to code within the context of the virtual arts. It is built on top of Java programming language. Processing programming language containing over 100 graphics libraries of OpenGL and Direct3D can generate various 3D graphics. The virtual reality environment in the paper is built by Processing 2.0 based on the analysis of above. Figure 1 shows our virtual reality simulation.



(Figure 1) Building a creation in our LEGO program

Learners can select one brick in the left-side panel and stack it on the plane. The selected block can be moved and rotated by mouse and keyboard easily. For moving the brick on the plane, we must know the hovered position of the mouse on the plane. However, Processing does not provide any library to check collision between objects. Therefore, we propose a new approach which can support programmers who are being familiar with the Processing 2.0 programming language can easily to detect the interactions. The method consists of the following steps. First, we create an XML file to define each brick’s box collider. A box collider is determined by the position, size, and angle of rotation. The following code is an example of declaring a simple XML file:

```
<boxcolliders numberofboxcollider=”1”>
    <box id=”0”>
        <position x=”0” y=”0” z=”0” />
        <rotation x=”0” y=”0” z=”0” />
        <size width=”2” height=”1” depth=”1” />
    </box>
</boxcolliders>
```

In the next step, we use OBB (Oriented Bounding Box) algorithm to check collision between objects. To move a brick on the plane or a stacked block, we check collision between the mouse ray and the plane’s box collider or the stacked brick’s box collider. Therefore, the selected brick

will be rendered at the user's mouse position. The code of collision detection algorithm is as follows:

```
checkCollision (box, mouse_ray_info)
// box is the box collider, and mouse_ray_info is the information of the mouse ray
{
  nearest = null;
  // nearest is the nearest collision position
  for (int i = 0; i < eight; i ++)
  // eight is the number of the surfaces of box
  {
    if (collision happened between the No.i surface and the mouse ray)
    {
      if (the collision point is inside the surface)
      {
        if (nearest is null or closest is further than the collision point)
        {
          Set value for nearest is the collision point;
        }
      }
    }
  }
  if (nearest is not null)
  {
    return collision;
  }
  else
    return no collision;
}
```

By applying the new approach to interact with the virtual Lego-Like bricks, students can easily assemble any model imaginable in a virtual reality environment.

4. Experimental Results

We developed an application of Virtual Reality in E-learning based on LEGO-Like bricks assembling using Processing 2.0 programming language. We ran the game on Windows 10 Pro. The test platform was a CPU 3.6GHz Intel Core i7-4790, NVIDIA GTX 970 graphics card as well as 32GB of RAM. Our game run fast and smoothly with 30 fps (frames per second) on average.

In our experiments, two simple models are modeled using technic bricks and special bricks which designed exclusively for our application as shown in Figure 2.

(Figure 2) Elephant and Giraffe

5. Conclusion and future work

The paper explores educational uses of an e-learning environment in combination with VR technology. It also describes the purpose of education and simulation by building a virtual reality environment with Processing 2.0 based LEGO-Like bricks assembling. This virtual learning environment provides a new study method for students to understand of certain events which have proven inappropriate and difficult in traditional education. Moreover, we present the virtual reality application based on the assembly of bricks to increase math and science learning by improving spatial thinking. It not only encourages students to pursue careers in science, technology, engineering, or mathematics but also enhances learners' ability to analyze and solving problems. Meanwhile, it saves a lot of time for teachers to improve teaching method and teaching quality.

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