

Physic Simulation Experiments using Augmented Reality

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Abstract—Augmented Reality (AR) is a technology which render visual information such as three-dimensional (3-D) virtual objects and allow users to interact with virtual and real object at the same time. This technology can help student to learn intuitively and interactively through simulation which is equipped with AR. This paper discusses the physic simulation such as force, gravity, friction, spring, gears and chain through AR. The system that we built is deployed on mobile platform specifically Android based devices and based on marker-less AR. Instead of a black-and-white square marker, we use image corresponding the context to trigger and visualize the simulation. By simply touch the correspondent image, student can interact and alter the course of the physic simulation.

Keywords—augmented reality, marker-less augmented reality, educational aid, physic simulation.

I. INTRODUCTION

Augmented reality superimposes information – textual, figural event temporal video or multimedia contents– onto parts of the real world. Its capability includes render visual information such as three-dimensional (3-D) virtual objects and allow users to interact with virtual and real object at the same time. This technology can help student to learn intuitively and interactively through simulation which is equipped with AR.

Traditional methods of educating students such as printed books, have well-proven advantages, but some deficiencies have also been identified [1]. Physics can be studied by watching natural phenomenon, such as gravity (Newton Law), action-reaction, and friction. This can be done by setup some real life experiments, of course they require not only printed books.

Other than the printed books, using the experiments as teaching delivery method is desirable, because they show students in real life how things interact in a natural way. However, these experiments are costly and need special environment in order physics experiments take place properly and correctly.

Fortunately, with the recent development of IT (Information Technology), a promising and effective way of 3D visualization called AR, which combines computer-generated information with the real world, and it can be used successfully to provide assistance to the student necessary to carry out difficult experiments and to understand complex problems [2].

An overview of existing AR systems in education and learning has been presented in [3]. One example is educational application is an experimental system that demonstrates how to aid teaching undergraduate geography students using AR technologies [4].

In this paper, we propose one example prototype of educational application that aid students to learn physics laws using marker-less AR technology that developed in Android gadget.

II. DESCRIPTION OF WORK

We develop a marker-less AR based application to help students study physics law, that consists of 8 (eight) modules presented in 3D (three dimensional) environment. Marker-less AR needs image target that is designed and printed on glossy paper. Each experimental module is designed as one experimental page and accompanied by a brief description page. These glossy papers are bundled together as single “magic book” for students to learn physics phenomenon.

Eight designed modules are:

- a. Swing
- b. Rolling down a ramp
- c. Seesaw
- d. Friction of sliding object
- e. Galileo’s inclined planes
- f. Parachuting
- g. Springs
- h. Gears and chains

These eight modules refer to Newton physics law which include friction, resilience (spring), air resistance, gravity, acceleration and transmission.

We develop the software using Unity3D, which has many necessary functions such as physics engine, 3D graphical objects, animation and support for 3D object created by 3D software such as 3ds Max, Maya and Blender, while also support textures made by image editors. To implement AR capability, we utilize Vuforia platform from Qualcomm. Figure 3 shows overview of our system.

To facilitate interaction virtual object with student user, virtual button feature is utilized. For example, to modify the balance of a seesaw, virtual button is placed on fulcrum. By dragging the fulcrum from center of the seesaw --to the left or to the right-- student can see the effect of shifting the balance of the seesaw as illustrated in Figure 1.

Each page is graphically designed as such it correspondent with its respective module with regards to aesthetic and better understanding. For example, seesaw module is represented by image of two children sit on the seesaw. Not only dragging the fulcrum, student can also choose the weight of load (1 kg, 2 kg or 4 kg) as shown in Figure 2.

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Modules design are inspired by Algodoo, a software which enable students to create simulation scenes using simple drawing tools like boxes, circles, polygons, gears, brushes, planes, ropes and chains. In addition, students can add more physics in the designed simulation like fluids, springs, hinges, motors, thrusters, light rays, tracers, optics and lenses. Algodoo also allows students to explore and play around with different parameters like gravity, friction, restitution, refraction and attraction.

For marker-less AR to work, it requires a unique pattern defined as image target which is disguised and inserted into a printed page which bundled in the designed magic book. Uniqueness of a pattern in image target is needed to identify which module selected from 8 modules that will be presented to a student. It is one to one mapping relation, i.e. one unique image target for one specific module. Quality of pattern's uniqueness is evaluated by Vuforia platform which will display a score. The higher the score, the better the quality.

As a design example from all of the modules, in this paper we pick seesaw module. Figure 3 shows how seesaw module is designed. Programmed virtual button is embedded in "A" object (fulcrum), as such that user can "push" the button (by "touch" it) and slide it to the left or to the right, to shift the fulcrum, hence modify the balance of the seesaw, shorten and lengthen the lever arms. We implement pushing the fulcrum by give a certain force i.e. 10N to the fulcrum to the right or to the left.

The weight of "B" box can be modified using Rigidbody variable in Unity 3D. By modifying the weight (mass variable) of "B" box on one arm --on other arm is "C" box--, students can see the effect. Virtual button 1, 2 and 3 will give weight to the load 1 kilogram, 2 kilograms and 4 kilograms respectively. For example, if "B" box is given 2 kilograms of mass and "C" box is given 4 kilograms, then fulcrum ("A") must be shifted (manually by user) to set the balance right. Students can try this experiment using a variety of combinations between modifying the mass of box and shifting (dragging) the fulcrum. Figure 4 shows all of target images and their respective placement of virtual buttons (green colored).

III. RESULT AND DISCUSSION

After software design and development using Unity 3D, Android Package (APK) file is ready to be deployed

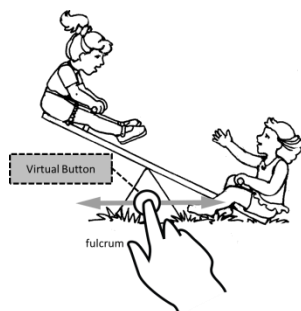


Figure 1. Virtual button is placed on the fulcrum so student can drag it to shift the balance of a seesaw

in Android tablet. In this research, we only test it on some Android tablets, such as Samsung Galaxy Tab and Samsung Galaxy Note 10.1. They both have quite big screen (compared to other Android tablets which generally have smaller screen size) to accommodate freedom of finger movement of user.

The printed magic book is placed in front of Android tablet. Using rear camera, we place the view of page to fit on screen and appropriate module is displayed correctly. Due to high score of each image target (which reflect its quality), every module is correctly mapped to each image target.

We then each module one by one regarding its simulation represents. Each module is tested and all of designed physics simulation is correctly simulated. We find that holding Android tablet in one hand and the other hand to tinker the experiment by "touching" object that is placed on module page (in front of tablet) is rather difficult. The better approach of conducting physics experiment using Android tablet employs marker-less AR is to place the tablet on holding stand (preferable with adjustable arm), so both hands of student are free to adjust the page of magic book or tinkering the objects.

IV. CONCLUSION AND FUTURE WORKS

Simulation of physics using marker-less AR is successfully implemented on Android tablet. In the future, we will test it on other tablet such as Apple Ipad IOS-based devices and develop more interesting physics (or chemistry) experiments.

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Figure 2. Seesaw module is graphically illustrated with two children plays seesaw

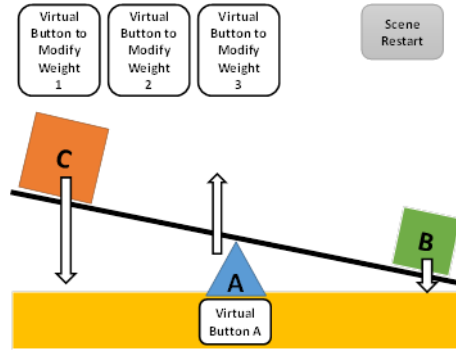


Figure 3. Seesaw physics simulation design

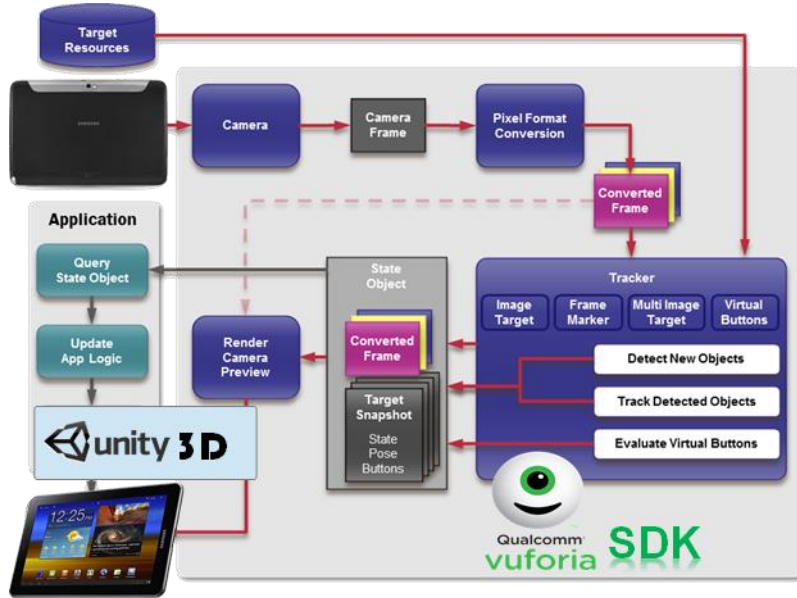


Figure 4. Overview of our system

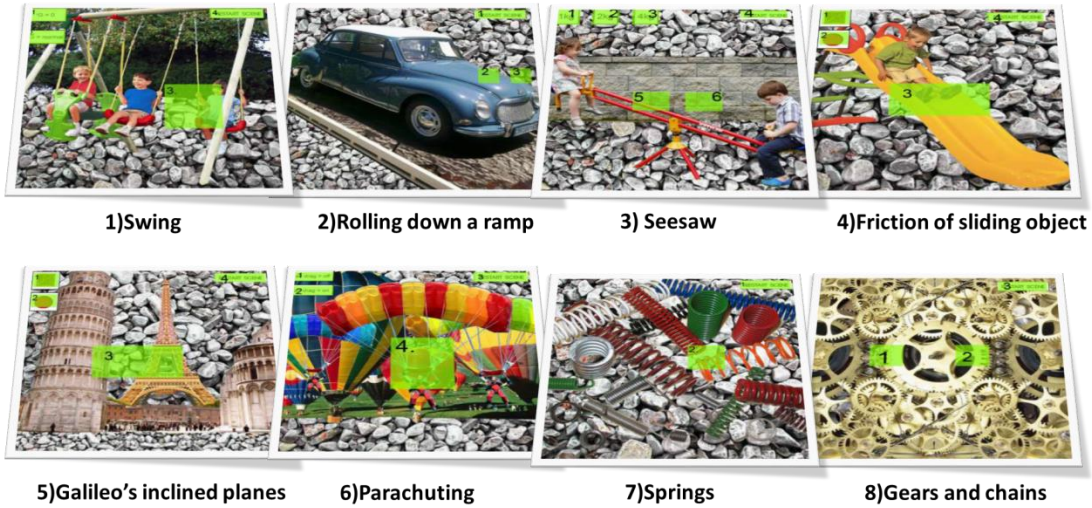


Figure 5. Image targets and their respective placement of virtual button (green colored)