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To Develop the Virtual Physics Laboratory by Integrating Kinect with Gesture Classification Algorithm

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Abstract—**Physics is an experimental science, which is through experiments for initiating students into physical concepts and principles. To motivate students in learning physics, in this study, a virtual physics laboratory was developed by using the techniques of Kinect, Unity3D and a gesture classification algorithm. The visual physics experiments were designed in the virtual physics laboratory. The experimental results show that the user can accurately interact with the virtual objects in the virtual physics laboratory, and the developed system provides an interesting way to assist students in learning physics.**

Keywords- Interactive Learning, Physics, Physical experiment, Kinect, Pattern recognition

I. INTRODUCTION

The most important thing for the children in the period of enlightenment is to learn effectively. Through thoughtful interactions, families and early childhood professionals can foster a child's scientific thinking, stimulate curiosity, and establish a foundation for a lifelong interest in science [1]. There are many different connotations of learning for children. However, the earnest learning materials in school are not attracted to the most students. Indeed, play is our brain's favorite way of learning things [2].

Recently, much technical stuff for education has continually being developed. As students get interested in the interactive digital games, the position of digital games is to assist students in studying materials in order to be both interesting and be learned actually. The students will be attracted to the approaches or learning tools essentially interesting to them. Many software games for education were developed to raise students' motivation and engagement [3]-[5]. In the area of human-computer interaction, embodied interaction is fascinating in an active way [6]. The embodied interaction in many ways having the possibilities to enhance educational technology was presented by [7]. In their opinions, the embodied interaction will take an enthusiastic effect on abilities such as problem solving, science and mathematical understanding. Good *et al.* [8] reported that children's cognitive performance and mental skills would be restricted by a mouse/keyboard. They argued that the embodied interactive device enables students to learn in a way combined with mental operations and physical actions [8]. Because of the technical evolution, the equipment of computer games has been greatly improved. In this regard, we present a Kinect based Interactive Physics Learning Environment System and demonstrate how students can play the educational physics software game via embodied interactions.

The organization of the paper is organized as follows. In Section 2, we introduce our proposed virtual physics learning experiment system. In Section 3, the SOM (self-organizing map) -based K-NN gesture classifier is introduced. We show the experimental results of gesture recognition in Section 4. Section 5 concludes this study.

II. VIRTUAL PHYSICS LEARNING EXPERIMENT SYSTEM

The virtual physics learning experiment system is created for students to learn physics by letting them interact with our virtual environment via Kinect (see Fig. 1). Since 3D games often can provide students with more realistic feeling of immersion, Unity3D was used to construct the 3D virtual environment due to its powerful 3D game engine. In addition, a multi-sensors board was designed to and interface with the virtual experiment. The board consists of four sensors, including a photo-resistor, a temperature transducer, an accelerometer, and a photo-interrupter. The board outputs the detecting results of four sensors to simulate the physics phenomena of interest. The results were also fed back to the learning experiment system through Bluetooth.
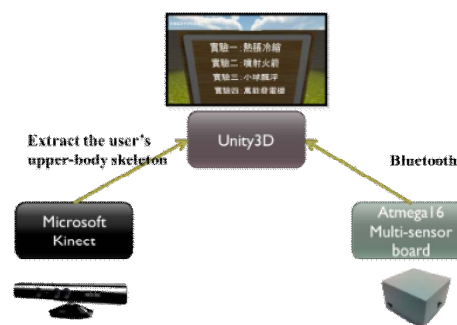
Fig. 2 shows the visual thermal expansion/contraction

Fig. 1. The virtual physics learning experiment system

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experiment. In this visual experiment, each learner should find a way to control the size of the virtual hole, which reflects the readings from the temperature transducer. In the electricity generation experiment, as shown in Fig. 3, the virtual light is determined? by the virtual power energy. Through this virtual energy experiment, the learner can learn how to produce the power.
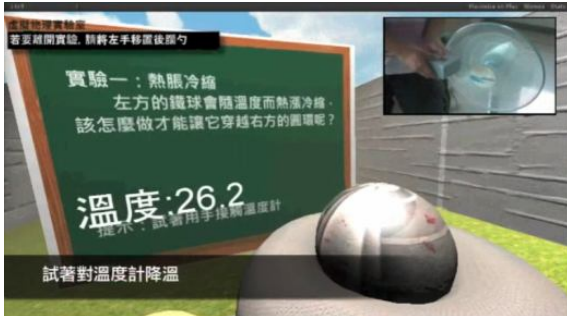

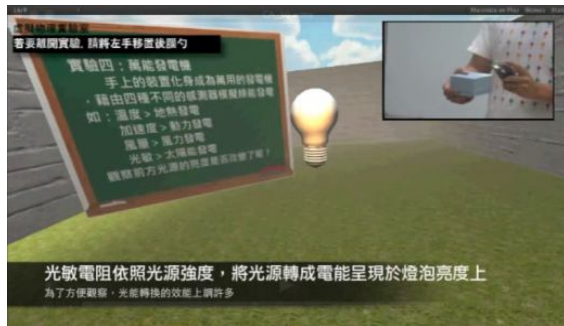Fig. 2. The visual thermal expansion/contraction experiment.

Fig. 3. The electricity generation experiment.

III. The SOM-based K-NN gesture classificatoin method

Step 1. Generating gesture-vector: The user's upper-body skeleton is extracted from the Kinect and there are nine nodes in the upper-body skeleton. The gesture-vector must be normalized in accordance with the space, so the coordinates of the nodes would be subtracted?? From the coordinates of the shoulder center node.

Step 2. Generating multiple gesture-vector templates: We use the collected sequential gesture data, which are unlabeled, to generate multiple templates.

Step 3. SOM training procedure: The SOM projects the sequential gesture data into a 2-dimensional trajectory.

Step 4. Generating the trajectory-vector: When step 3 constructs a SOM, the sequence of a gesture-vector is sequentially input to the SOM to set the corresponding winners on the SOM map.

Step 5. Normalizing the length of the trajectory-vector: Since the dimension of the trajectory-vector will be dif-ferent even with the same type of gesture, we need to normalize the dimension of the trajectory-vector.

Step 6. K-NN for trajectory classification
Finally, K-NN classifies the matched trajectory with the multiple templates of each gesture.

IV. Experiment

We proposed a SOM-based K-NN gesture classifica-tion method to recognize the 4 gestures, as shown in Fig. 4. Then, we collected the sequential gestures of the users' upper-body skeletons and we set the threshold of variation to generate multiple templates for the sequential gestures in every frame. The performance of the 4 gestures were tested. All users posed each gesture for five times. In the table 1, the evaluation of 4 subjects is presented.

Fig. 4. Four gestures, which consists of quitting game, next game, last game, and shake were tested the perform-ance of our system

Table 1. The performance of our system tested by four users.

Users' Height	1st	2nd	3rd	4th
178cm	100%	100%	100%	80%
171cm	100%	100%	100%	100%
174cm	100%	100%	100%	100%
176cm	100%	100%	100%	80%

V. Conclusion

In this study, we constructed the virtual physics learning system and designed visual physics experiments so that users can interact with our system via a Kinect. The Kinect can be used to detect users' upper-body skeletons, which represent the corresponding gestures of the users. The users will interact with the system through 4 gestures. The performance of our system is 80-100%, which is a promising result to provide an interesting way to assist students in learning physics.

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