# Applying Kinesthetic Real-time Interactive Technology to Develop a Martial Arts Learning System

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**Abstract:** Martial arts are one of China's traditional cultures and sports, practiced not only for self-defense but also for physical fitness and longevity. In modern Chinese society, where health consciousness has been gradually popular, more and more people are engaged in martial arts. By employing the hardware, i.e., Microsoft Xbox Kinect, the authors developed a 3D kinesthetic learning and evaluation system for martial arts. The system provides real-time feedbacks so that learners can understand immediately adjust their postures; meanwhile, it evaluates their learning performance. Analysis of variance (ANOVA) will be adopted to explore the different performances resulting from this system, the traditional method, and common multimedia computer-assisted instruction (CAI). Thereafter, the scores given by the automatic evaluation system would be compared with those given by traditional human evaluation. It is expected that this study can contribute to CAI-based physical education as well as for the martial arts promotion in the future.

**Keywords:** Martial Arts, Kinesthetic Learning, Computer-Assisted Instruction

## 1. Introduction

With the rapid progress of science and technology, people's lifestyles have been changing constantly. In 2006, Nintendo launched the video game console Wii; in 2010, Microsoft released the kinesthetic game console Xbox Kinect, which revolutionized the rules of traditional games. Also in 2010, at the annual event of International Consumer Electronics Show (CES) held in Las Vegas, Steve Ballmer, Microsoft's chief executive officer (CEO), confirmed in his opening speech that the year 2010 would be vital to Xbox, for Xbox 360 + Kinect had successfully ushered in a brand-new era of kinesthetic games. Moreover, in 2011, Google offered reverse image search services to consumers while Apple iPhone 4S provided voice recognition services through the application Siri. At another CES event in early 2012, Intel vigorously displayed its ultra-thin sub-notebook Ultrabook, which is capable of voice control. The fact that major electronics manufacturers have successively focused on human-computer interaction (HCI) clearly indicates that voice control and kinesthetic applications have become indispensable technologies if a leading manufacturer desires to differentiate its products from those of its competitors. According to a survey conducted by CES, more than 1750 sets of Kinect had been installed globally by the end of 2011 representing a market share of 68.7%. The above figure shows how popular kinesthetic games are nowadays around the world. Relying on built-in cameras to capture the user's movements in a 3D space, Xbox Kinect allows the players to interact with the characters and objects in the game. Such a feature enables users to practice motor skills in the game environment; therefore, it is highly suitable for teaching and learning sports [16].

Martial arts are different from ordinary sports in that the former not only are practiced for self-defense and fitness but also emphasize the cultivation of virtue and cognition. Lakes and Hoyt (2004) compared martial arts with traditional sports concluding that martial arts significantly enhanced children's cognitive, emotional, and social behaviors [10]. Brudnak, Dundero, and Van Hecke (2002) studied the effects of martial arts on the elderly's health [3] and concluded that soft martial arts (for example, Tai Chi) as well as hard martial arts, which are faster and more energy-consuming, can provide muscle-training exercises for elderly people and thus contribute to their good health. Kang (2000) proposed that besides being good for fitness and self-defense, martial arts blend muscular and aesthetic elements of bodily movements [9]. Traditionally, martial arts are learned through a master's face-to-face instructions, or through films and written materials, the latter of which are a learning platform deficient in feedbacks.

With the help of the kinesthetic devices of Xbox and the game engine Unity, this research aims to develop a 3D kinesthetic learning and evaluation system for martial arts, which can provide real-time feedbacks for users. Its 3D visual angle enables learners to grasp the positions of their bodily parts in space when they are practicing. Furthermore, the system can provide real-time feedbacks for learners informing them whether their postures are correct or not.

To prove its positive effects on the learning of martial arts, a test was conducted. Thirty students of martial arts major were randomly selected and divided into three groups. The three groups would be assigned to learn respectively through the traditional method, common multimedia-based CAI, and the 3D kinesthetic learning system. Toward the end of the test, their learning performances would be evaluated with a questionnaire survey . The analysis of variance (ANOVA) would be adopted to explore the different performances between this system and the other teaching methods. In the past, evaluating the performance of martial arts was usually done by a teacher's subjective judgment. In this research, objective evaluation would be performed by capturing the positions of a learner's body parts by Xbox Kinect. In that way, whether or not the learner's postures were in the correct spatial positions would be decided by the computer system, whose judgment is much more objective. Finally, the evaluation results of this system would be compared with those of traditional teachers to establish a computerized evaluation system for the learning performance of martial arts.

## 2. Literature Review

### *2.1 Motor Skill Learning*

Fitts and Posner (1967) suggested in his study that learning motor skills always undergoes three stages [6]. In the first stage, called the cognitive phase, learners grasp every correct movement cognitively; thereafter, further practice links up all the movements necessary to a particular skill. In the second stage, or the associative phase, learners acquire a series of independent movements through repetitive practice converting them into a fixed set of responses. In the third stage, the autonomous phase, the above movements have gone through the process of chain orientation. After long-term practice, coordination of specific movements is free of cognitive elements. In other words, those movements have become an unchangeable habit; as a result, the motor skills are mastered and the learning task is successfully completed. Newell et al. [14] presented a dynamic view theory suggesting that when the human cognitive system receives concrete symbolic codes and memorial symbolic codes, the visual system will automatically transmit the messages about an observed action and provide them for the responsive system. Thus, the visible movements of learners will be more harmonious, graceful, and consistent. Magill [13], an expert in motor skill analysis, concluded that if some key dynamic features or kinematic elements are provided in the process of demonstration, learners' attention and cognitive powers will be aroused. Thus, a favorable environment where motor skills can be learned is created. Angleman, Shinzato ,Van Hasselt, and Russo [1] proposed that both traditional martial arts and modern self-defense skills take constant practice so that their memories may become natural responses. Afterwards, in the face of immediate threat, learners will perform defensive actions without thinking. From the above literatures, it can be seen that motor skills should be learned through cognition and constant practice. Also, practice should be executed in an environment where feedbacks about any movement can be provided. The feedbacks will then be memorized as well as absorbed by the body to become natural responses. This study is aimed at developing a cognitive 3D learning system for martial arts, which is capable of providing dynamic demonstrations and feedbacks or hints on movements. What's more, the system enables users to learn continuously.

### *2.2 Computer-aided 3D Kinesthetic Learning*

Leite, Svinicki, and Shi [11] suggested that there are several types of learners, such as visual learners, auditory learners, reading-centered learners, writing-centered learners, and kinesthetic learners. As for tactile learners, they are classified under the category of kinesthetic learners. BenZion [2] thought that a combination of two or more learning styles can be adopted, such as kinesthetic learning combined with auditory learning or other learning styles, to achieve a better result. Influenced by the above mentioned theories, this study mainly blended visual, auditory, and kinesthetic learning together, making a deeper research. Zhu [17] applied Web3D computer-aided technology to the learning materials of martial arts, with the focus on Zhong-yi Boxing routines. He discovered that 3D CAI was definitely different from traditional ways of 2D movie-based teaching and learning. Thanks to the former, such a problem as the limited observation angle was solved easily. Though kinesthetic learning is not covered by his study, Web3D CAI still provides an innovative concept of a learning interface for martial arts. Hämäläinen, Höysniemi, Lindholm, and Nykänen [8] applied artificial reality to the interactive games of martial arts. Their research did not concentrate on digital learning; however, the application of artificial reality to learning martial arts was an unprecedented attempt. In addition, Li [12] applied information technology (IT) to teaching and learning martial arts in elementary school. According to his study, those pupils who had learned how to apply IT to martial arts performed significantly better in terms of cognitive learning performance either before or after the test. Tsai [15] explored the effect of Wii Sports baseball games on pupils' batting performance. His research results indicated that kinesthetic learning evidently improved pupils' actual batting capabilities. Besides, it showed that the application of interactive multimedia not only raised learners' interest but also sharpened their skills.

## 3. Research Design

The research process is as Figure 1.

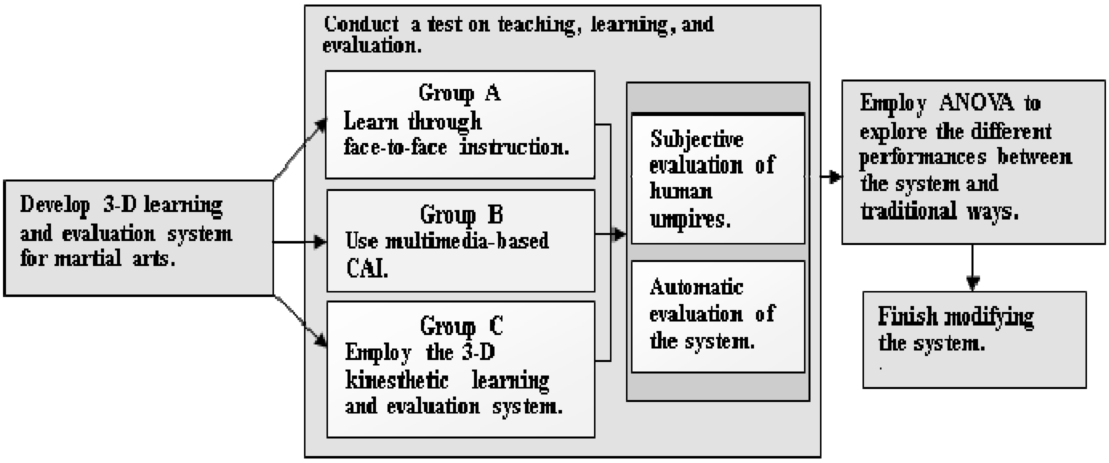


**Figure.1.Research Process**

This research first attempts to develop a 3D learning and evaluation system of martial arts. Then, thirty college students will randomly recruited participate in a test. They are aged between 18 and 40, regardless of gender. The learning materials of martial arts in this study are adapted from the Kung-fu materials contained in Section 11 of "Physical Education Materials, Teaching Methods, and Evaluation", established by Ministry of Education (MOE) in 1997.

Next, the thirty students will be randomly divided into three groups, namely, Group A, Group B, and Group C respectively, with ten members in each group. Group A will learn martial arts in a traditional way; Group B will use multimedia movies with captions; Group C will employ the 3D kinesthetic learning and evaluation system under discussion. The students will be taught for one hour a day, and the whole program will last for a week. At the end of the learning process, all the students will receive an evaluation test on their performance. For the purpose of comparison, there are two ways of evaluations. To be more specific, one way is traditional; namely, the masters of martial arts will give the scores personally. The other way is performed automatically by the new system. Before the evaluation test, each student will be allowed to practice the system operation for 10 to 15 minutes. It will be only after the students are found to be familiar with the system operations that the evaluation test will start.

The evaluation results will be analyzed through analysis of variance (ANOVA) to compare the different performances between the three methods. Meanwhile, it is expected to discover whether the new system is helpful to the learning of martial arts. Thereafter, the evaluation results obtained from the 3D kinesthetic learning and evaluation system and from the traditional evaluation method will be compared to determine their differences. The ultimate goal is to find out whether automatic evaluation of the new system could replace subjective evaluation of human umpires.

## 4. System Development

### *4.1 Production of System Contents*

As for the 3D digital contents of the system, the authors produced the 3D low-poly models of the roles and scenes through Autodesk Maya, which is a 3D computer graphics software. Next, a graphics processing software is employed to draw maps, including diffuse maps and specular maps. Moreover, normal maps were used to represent the details, corrugations, and concave or convex of the models. After that, shadow maps were used to make lightmaps without increasing the lights. Thus, the illuminated environment was simulated, with the waste of system resources reduced. As the role was finished, its compatible skeleton was fitted. Then, the related data were entered into the interactive game engine, i.e., Unity3D, to edit the interactive control program. In this way, the player's motor data captured by a Kinect camera could be converted into the skeleton data, which would be used to control the skeleton of the 3D model correspondingly.

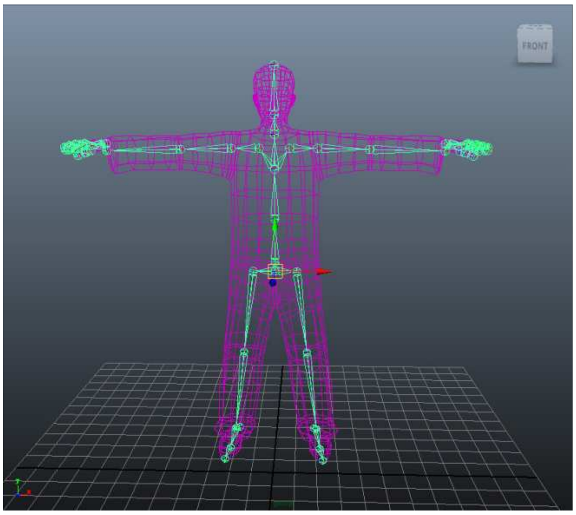

**Fig. 2. The diagram of the role's simulated skeleton**

*4.2 Sound Effects of the System*

The sound effects of this system were chiefly produced through the software Pro Tools, which is a digital audio workstation platform for Microsoft Windows and Mac OS X operating systems. It was developed and released by Digidesign forming a part of Avid Technology. It is used to record and edit music, to produce the background music of movies, and to handle film or TV post-production. Therefore, it is a desirable choice to apply the specialized software to produce the sound effects of this system. Since this study was directed towards the learning of martial arts, its main concern fell on the rhythm of movements. In consequence, the rhythms of drum beats were adopted as the primary background music in this system.

*4.3 Connecting Hardware and Software of the System*

As for the development and construction of the connected hardware and software, the system mainly used OpenNI as the middleware to connect Kinect to the applications developed by the authors through the software Unity3D. OpenNI defines all the application program interfaces (API) needed to compose natural operation programs; thus, it provided a cross-platform structure as well as a standard interface. As shown by the schematic diagram in Fig. 3, the system was divided into three layers. In the top layer were some applications, which were developed by the authors through Unity3D. In the bottom layer were four main kinds of hardware supported by OpenNI:, namely, 3D sensors, an RGB camera, an IR camera, and audio devices. At present, the employment of OpenNI was mostly directed towards the hardware Kinect. It was in the middle layer that OpenNI was located. OpenNI was responsible for not only communication with the hardware but also for gesture recognition or signal-tracking, the latter of which would be handled by the middleware installed later. Regarding the middleware, OpenNI currently defined four components below: 1) Analysis of the whole body. The sensors obtain and produce information about the body, such as that about joints, relative positions and angles, as well as the center of mass. 2) Analysis of the hand. It means to track the hand. 3) Gesture detection. It means to recognize the predefined gesture, like hand-waving. 4) Analysis of the scene. It means to analyze the information about a scene, such as to separate the foreground from the background, to give the coordinate axes of the floor, and to identify the different objects inside the scene.

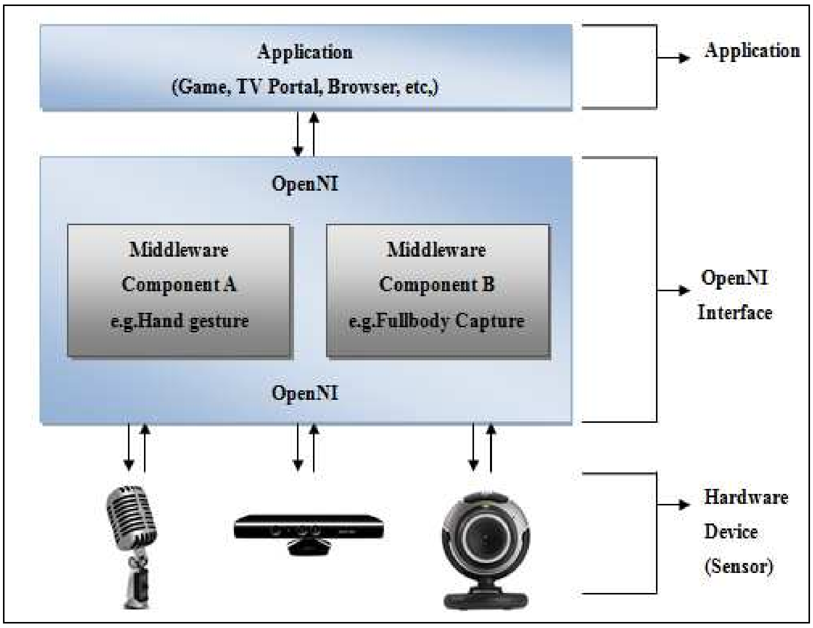


**Fig. 3. The schematic diagram of OpenNI**

Among the four components mentioned above, analysis of the body was most frequently used by the system. To be more specific, after Kinect captured the data about image recognition, NITE was employed to convert them into human skeleton data, as shown in Fig. 4 . In the meantime, the player's skeleton, which was developed through Unity3D, was activated and controlled synchronically to play the game. Then, the embedded NiUserTracker in OpenNI could be used to view the real-time data of the converted skeleton, as shown in Fig. 5.

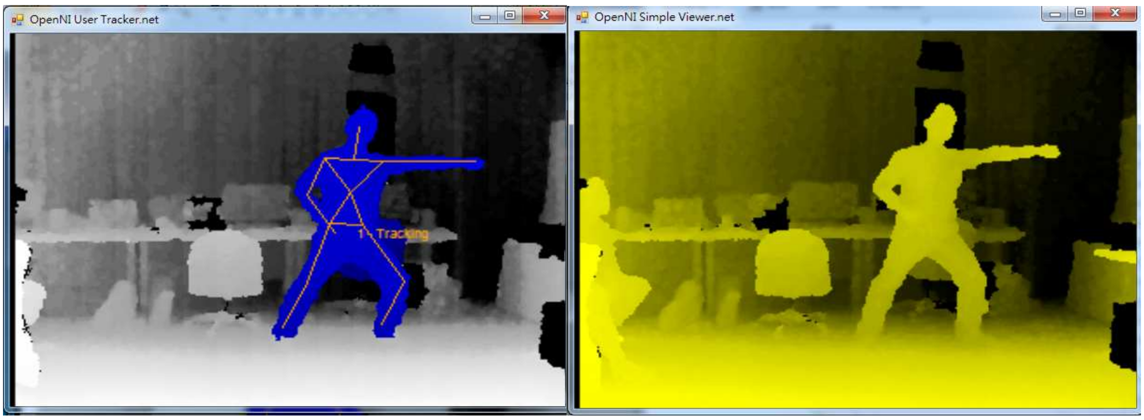


**Fig. 4 (left). The real-time skeleton data displayed by NiUserTracker**
**Fig. 5 (right). The skeleton data in OpenNI making real-time control over the skeleton of the player in the system**

*4.4 Real-Time Analysis and Feedbacks*

Kinect captured the 3D real-time data, which included the xyz (fixed) system and the XYZ (rotated) system, about the user's body parts and limbs. Immediately afterwards, it would transmit the data via OpenNI to the applications of Unity3D. Then, a user could control the movements of the 3D digital role right away. When the user followed the scripts of learning materials for martial arts, which were developed by the system, the name of a particular posture would be displayed on the screen. Thus, the user would understand the correct name of a set of related movements. Moreover, the set of movements would be demonstrated on the screen three times so that the user might watch and practice. Next, the kinesthetic learning came into play. At first, the system would show the name of a certain posture for the user to perform, such as "Stride and Attack with Clenched Fists." After that, accompanied by the rhythmic drum beats, the system would display blue circles on the screen reminding the user of the correct positions of the hands; meanwhile, blue footprints were also displayed reminding the user of the correct positions of the feet. As the user followed the drum beats and moved his hands or feet onto the correct positions, the blue circles and footprints would turn green immediately. It meant that the user's posture was correct. On the contrary, if the user's hands or feet were not moved to the proper positions, the blue circles and footprints would turn red. It, of course, meant that the positions of the user's hands or feet were wrong. As shown in Fig. 6, the user's two hands and left foot were in the correct positions so two circles and one of the footprints turned green. Contrarily, the user's right foot was in the wrong position so its corresponding footprint turned red. By means of real-time feedback, the system enabled users to learn efficiently.


**Fig. 6. Real-time feedbacks provided by the system**

## 5. Conclusions

With the advancement of science and technology, people have had more and more diversified ways to get information and acquire knowledge. For that purpose, digital learning remains an important link of science education and research. We should never confine ourselves to traditional ways of learning without any change. Instead, we should both retain the advantages of traditional teaching approaches and employ modern scientific means so that more learning potentials may be fully realized. Besides being an athletic skill, martial arts are a fruit of strength and beauty testifying to our ancestor's wisdom. Domestic studies on the teaching and learning of martial arts still exist in the framework of face-to-face instructions. By contrast, some foreign studies have introduced digital technology to the learning of martial arts. Since the application of kinesthetic devices to martial arts is just at the developing stage, it has attracted many researchers' attention. Therefore, the authors utilized the good qualities of kinesthetic devices to develop a learning and evaluation system for martial arts. In addition to provide real-time feedbacks for learners, the system is capable of evaluating learners' performance automatically. It is hoped that the system may contribute to the popularity of martial arts as well as offer a new approach and suggestions to the learning and evaluation of physical education.


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