Thesis
An Exergame for Encouraging Martial Arts

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Abstract

In this paper, we developed a game-based learning system for martial arts with the aid of Kinect sensor, stressing the importance of providing the player with immediate feedback, clear goals and challenges that are matched to his/her skill level. Inevitably, games have unique opportunity to motivate, to inspire and to create appealing experiences. Why not we have them kill two birds with one stone? Game-based learning system often involved the process of gamify an existing knowledge learning system, which is a very difficult task due to the complexity of game concepts itself in addition to the on-going debate, yet to be determined underlying values that contribute to flow acquirement. Our idea is to get player to have fun with physical game, if possible, learn some real martial art skillsets from the gameplay. Hence, we have posited another plausible way, which is to edify an existing exergame system by add-on physical skillsets as part of the game challenges without obstruction to the game harmony. We have compared both wearable sensor (TSND121) and Kinect sensor for its suitability for body area network device. We found that Kinect sensor outperformed TSND121 with the features of no latency, high accuracy, affordability, ease of programming, on top of it’s controller-less and unobtrusive feature over wearable sensors. Hence, we are convinced that Kinect sensor is a more suitable sensor for body area network device in an exergame. As well, we discussed about punching gloves that possess influence on player’s psychological processes that was evident in our experiment result, exhibit the potential to govern game-based learning process. We posit that reality tool is essential in the future exergame learning system due to it’s virtual reality impact on player’s feeling. The game-based learning model discussed in this paper can be extended to other sports, especially those required sports equipment such as racquet, golf club, baseball bat and etc for high excitement, fun and interactive learning achievement.
List of Contents

1 Introduction
   1.1 Background ......................................................... 1
   1.2 Research Motivation ............................................... 2
   1.3 Structure of This Dissertation ................................. 3

2 Related Research .................................................. 4
   2.1 Multimodal interaction system for Education ................. 4
   2.2 Physical Training System ....................................... 4
   2.3 Serious Game ..................................................... 5
   2.4 Game Based Learning System ................................... 5

3 System Requirement ................................................ 7
   3.1 Sensor .............................................................. 7
   3.2 Interactive model ................................................ 8
   3.3 Assumption ......................................................... 9

4 Design ............................................................... 10
   4.1 Game Design ...................................................... 10
   4.2 Consideration .................................................... 11
   4.3 Limitation ......................................................... 11

5 Implementation ....................................................... 12
   5.1 System architecture ............................................. 12
   5.2 Hardware and Software ......................................... 13
   5.3 Rule and Logic ................................................... 13

6 Evaluation ............................................................ 14
   6.1 Sensor .............................................................. 14
   6.2 Experiment ......................................................... 15
   6.3 Result ............................................................... 16

7 Discussion ............................................................ 18
   7.1 Enclothed Cognition ............................................ 18
   7.2 Governance with reality tool .................................. 18
   7.3 Peers competition a good motivation .......................... 18
8 Future Work

8.1 Reality tools for exergame ........................................... 20
8.2 Sound and Haptic feedback for virtual reality ...................... 20
8.3 Game concepts to boost up training .................................... 20

9 Conclusion .................................................................. 22

References ..................................................................... 24
List of Figures

2.1 Experiential gaming model. [13] ................................. 6
3.1 Sensors: (a) TSND121 (b) Kinect .............................. 8
3.2 Interactive model .................................................. 9
4.1 Game Flow .......................................................... 10
5.1 System Architecture .............................................. 12
6.1 Punching gloves ..................................................... 15
6.2 Time taken to make 30 punches ............................... 16
6.3 User survey results ............................................... 17
List of Tables

1.1 Brief history of video games .................................................. 2
Chapter 1

Introduction

Parents or babysitters may be familiar with the following scenario; children threw their hands up in the air and shouted hurrah for game hours, however, the opposite happened when it comes to formal learning. This clearly shows that people are always looking forward to gameplay, because games are always related to fun, exciting and addicting. On the other hand, people tends to react reluctantly when they are told to go for training or learning, because training or learning are often associated with boring, formal or even soporific. It will be grateful if game can be part of our formal learning system. The idea of embedding education into entertainment started as early as a few decades ago. Edutainment was introduced in 1954 when Walt Disney began to build Disneyland. [19] The excitement brought by entertainment and the invocation of emotions such as curiosity, joy and pride by game are similar to the key points of a successful education system. It was mentioned by Marc Prensky [27] that our traditional learning system, which worked well for hundreds of years is breaking down while the learning through Digital Games is a wave of the future. Now, game-based learning is a wave of the present.

In fact, we learned through games when we were very young. During our toddler days, every aspect of life: eat, speak, walk was games. We started to differentiate colors by color hunt game – hunt for something red or blue or green at home, the game often ended with lots of laughter and we gained new knowledge inadvertently. However, the game was replaced with textbooks and lecture when we enter school. Traditional textbooks and lecture were found boring for students who grown up in a pervasive technology environment, hence, educators introduced game-based learning in the classroom. The effectiveness of game-based learning was evident by [5], students scored significantly higher with the aid of gameplay in classroom. At present, the number of game-based learning systems is huge; the varieties are range from mathematic to science, history to politics, literature to sports and etc. The invention of highly reliability and inexpensive sensors such as Kinect and Wii had boost up the opportunities to develop game-based learning system for dynamic activities including various sports and dances that required emphasize of gesture movement.

1.1 Background

Video games have evolved from mainframe computer games during 1950s into controller-less games at the present. Table 1 listed the dramatic growth in video game industry. There are many recent games that involve gesture movement associated with sports, dance and martial arts including Kung
Fu Panda 2 Kinect, Kinect Sports, Dance Central 2, Fighters Uncaged, Wii Sports Resort, Punch-Out!! and etc. All these mentioned games are fun to play, appealing, fascinating, and absolutely qualified as a successful game. However, these games do not teach players the real sports skills. I regret that a player who scored well in a golf game might not even know how to hold a golf club in the proper way in reality. What a pity for the player to invest substantial amount of time in the gameplay but did not acquire the real sports skills.

Table 1.1: Brief history of video games

<table>
<thead>
<tr>
<th>Year</th>
<th>Popular video games</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s – 1960s</td>
<td>Mainframe computer game</td>
</tr>
<tr>
<td>1970s</td>
<td>Video arcade games</td>
</tr>
<tr>
<td>1980s</td>
<td>Home computer games</td>
</tr>
<tr>
<td>1990s</td>
<td>Handheld games</td>
</tr>
<tr>
<td>2000s</td>
<td>Mobile games</td>
</tr>
<tr>
<td>2010s</td>
<td>Gaming without controllers</td>
</tr>
</tbody>
</table>

*Note: Summarized from Time*¹

Exergame was first introduced in the 1980s. It is a portmanteau of “exercise” and “game”. However, there were on-going debates for it’s definition between the traditional health-related researcher and the researchers who do not have a health-related background. In this study, we take the new definition by [23] that interpreted exergames as a combination of exertion and video games including strength training, balance, and flexibility activities while exergaming is playing exergames or any other video games to promote physical activity.

1.2 Research Motivation

In this paper, we would like to introduce an interactive digital system that promotes informal learning of martial arts, Karate. As concluded by [7], learning through games is meant to replicate children’s more natural style of learning, then making them less like play and more like schoolwork will render them ineffective as educational tools. Game-based learning systems design often applies game concepts into existing education system. We suggest the other way round, which is to include martial art skillsets into existing game system design. Hence, we propose a game-based learning system that look and feel exactly like an ordinary video game that could unobtrusively teach player about martial arts during the gameplay. The ultimate goal is to have the player indirectly learn the real sport through the gameplay. As well, we explore the feasibility to utilize real sports tools in exergame learning system. We hope the encouraging findings about exergame as supportive tools to formal learning in this dissertation can contribute to the future of fun yet educative game systems that support all conventional learning styles including auditory, visual, and kinesthetic that could benefit huge varieties are range from mathematic to science, history to politics, literature to sports and etc.
1.3 Structure of This Dissertation

The remainder of this dissertation is organized as follows. We discuss about related research in the next chapter. In Chapter 3, we probe into the requirements of an exergame. In Chapter 4, we explain about the system design and detailed implementation is revealed in Chapter 5. In Chapter 6, we present the experiment findings and the evaluation outcomes are discussed in Chapter 7. We share our thoughts for potential future work in Chapter 8 and we conclude the dissertation in Chapter 9.
Chapter 2

Related Research

2.1 Multimodal interaction system for Education

Hsu explored the potential of Kinect as interactive technology and discussed how this device can facilitate and enhance teaching and learning in [15]. She pinpointed that Kinect has the ability to create enjoyable, interesting interaction types, to boost motivation, and to promote learning via its multimedia and multi-sensor capacity. The paper concluded that Kinect has high potential despite having technical constraints such as limitation of space required. However, the paper did not present the findings about accuracy and efficiency of Kinect as an interactive tool for physical activities such as sports.

A physical instructional support system was built in [22] with the aid of Kinect to provide a means of real-time direct communication. The paper emphasized on the importance of imitation learning and proposed a virtual training system for both the trainer and trainee to interact with their superimposed avatars via Kinect. Kinect sensor was used in the context of supporting tools where a human being instructor still plays an important role in this teaching-learning process.

2.2 Physical Training System

Thai boxing is inevitably known as one of the famous martial arts. Correctness of practice and proper postures were regarded as important in [26] to avoid sportsman injury. They modelled 3D avatars by motion capturing 2 actors with 42 spots on their bodies. The 3D avatars presented in this paper were lively and vivid, represented real Thai-boxing art. The results revealed that these animations helped the learners gain interest in Thai culture, although they have not personal experienced it yet.

An artificial reality martial arts game installation was being discussed in [24]. In this game, the player fights with virtual enemies with kicks and punches. It was mentioned that the game worked well for entertainment and fitness application, the motion exaggeration was found fun in the game. However, most of the participants for this user study practiced more than one sports and all of them were adults. Hence, the impact and benefits of this game to the novice were unknown. It was concluded that this system can be considered to develop motion skills and fitness but it is insufficient from an educational point of view as martial arts are about mind and body, harmony and respect to fellow trainees.
Authors in [12] explored the potential of motion training system that maps the user’s image onto an instruction video. This training system targeted first time learners for dance and evaluated the usefulness of presenting them composite video in which beginners appear to dance like an expert. The outcome is encouraging where people like to see themselves performed well, similar to the exaggeration fun in [24].

2.3 Serious Game

Serious games are often designed for a primary purpose other than pure entertainment. In general, “serious” refers to products used by industry in the area of education, military, healthcare and etc. Recently, “Games with a Purpose” are used to solve open problems. According to Luis in [31], “human computation” paradigm has enormous potential to address problems that computers can’t yet tackle on their own. While Game-based learning is described as “a branch of serious games that deals with applications that have defined learning outcomes” in [30], we will further discuss about this in section 2.4.

On top of the serious game advantages mentioned by Corti in his paper [9] “allowing learners to experience situation that are impossible in the real world for reasons of safety, cost, time, etc.”, serious game is argued to have positive impacts on the players’ development of a number of different skills. While there were debates about the negative impacts of violent games, several studies such as [2] and [3] were carried out but no evidence was found to indicate the negative effects of game. Hence, we are not able to draw a conclusion due to the on-going open debate concerning the effectiveness and drawback of serious game.

2.4 Game Based Learning System

Csikszentmihalyi mentioned that flow is an experience people had when they “worked hard, not in order to get conventional rewards, but because the work itself was rewarding…” in [16]. The key to understanding flow is the concept of autotelic experience where people forget personal problems, lose their sense of time and of themselves, feel competent and in control. The studies of relation between flow and telepresence are being explored in [10]. The findings suggested that there is a significant correlation between flow and telepresence. The authors suggested that flow experience in virtual gameplay and learning may acquire an improved attitude of learning online.

Kiili discussed about factors that contribute to flow experience in paper [11]. He stressed the importance of providing the player with immediate feedback, clear goals and challenges that are matched to his/her skill level in educational computer games. Killi’s experiential gaming model that linked gameplay with experiential learning to facilitate flow experience is presented in Figure 2.1. This experiential gaming model consists of an ideation loop, an experience loop and a challenge bank. The heart is the core to sustain the motivation and engagement of the player by pumping appropriate challenges to him or her. From a motivation and learning point of view, the operation of the heart is to provide a player with challenges that are matched to his or her skill level in order to increase the likelihood of experience flow. However, Killi mentioned that it is impossible to predict how quickly a player’s skills develop while gaming which makes the designing of games hard. Adaptive games can be one of the solution but adaption must be considered carefully in
order to avoid bad usability, inappropriate challenges and objects that may break the harmony in the game world which bring less likelihood of experience flow.

Figure 2.1: Experiential gaming model. [13]

Significant grow in the publications of digital game based learning system related article from 2001 to 2010 were reported in [16]. It was found that most studies did not involve specific learning domains; instead mainly focused on the investigation of students’ motivations, perceptions and attitudes toward digital games. Conventional education subjects such as “Engineering”, “Language and Art”, and “Science” top the list of studies. However, dynamic activities learning system were not mentioned in this paper.
Chapter 3

System Requirement

We have identified five important elements that make up a good game based learning system. Mainly, high accuracy to ensure smooth interaction between the player and the system; goal oriented for player to work towards a goal, learn and practice the right way; virtual reality is important to make a system that look and feel familiar and relevant to core subject; a system with no latency to provide immediate feedback; and the game concepts that contribute to state of flow.

3.1 Sensor

We have explored two sensors in figure 3.1 to fit for the above purposes. Firstly, we used a small and lightweight accelerometer sensor – (a) TSND121\(^1\). Secondly, we tried with a controllerless 3D infrared sensor – (b) Kinect. TSND121 sensor is very small in size, 37mm(W) x 46mm(H) x 12mm(D) and light in weight, approximately 22g. In addition, TSND121 sensor can communicate wirelessly with PC on bluetooth connection. We tried to modify this sensor into a wearable sensor by attaching it on punching gloves. We have requested an experienced martial arts practitioner to perform a series of martial arts movement with both TSND121 sensor and Kinect sensor. It was amazing to find out that TSND121 sensor gave us high speed sampling at 1000Hz. Both sensors gave us satisfying accuracy as well as stable connection with PC. We interviewed the martial arts practitioner about his experience with both sensors. He revealed that he had great experience with both TSND121 sensor and Kinect sensor. However, he expressed his concern about

- Attachment of multiple sensors on body that may cause restriction on body movement.
- Martial arts involved a series of body movement, not limited to punches and blocks but kicks and self defence steps too. A single sensor may not be able to cater for all.
- In conventional training scenario, a concrete target subject is preferable in precision training, to measure the distance between you and target.

From the perspectives of martial arts, a punch action does not concern only on the hands, but on the body axis as well as legs movement too. However, it will be obtrusive and impractical to request a player to put on several wearable sensors on their hands and legs including body parts such as torso before a gameplay, which may lead to dilution of virtual reality elements and limitations

\(^1\)http://www.atr-p.com/TSND121.html.
on body movements. On the other hand, a single Kinect sensor is able to identity 20 joint points information, in addition to it’s ability to track multiple user at once. Taking into consideration of the cost factor, suitability for exergame and practicality of implementation, we have picked up a much more affordable and unobtrusive sensor, which is Kinect sensor for this study.

3.2 Interactive model

This exergame was designed to be interactive and effective game based learning system. Interactive provide a means of acting with each other, making immediate two-way communication possible between computer and player. Figure 3.2 illustrated the cycle of interaction between the player and the system, it has revealed the underlying technology that play important roles in realizing the five important element. Firstly, player’s movement can be tracked by Kinect sensor at the speed of 30 frames per second which could provide a mean of high accuracy to ensure smooth interaction between the player and the system. Then, the depth information is send over to Synapse\(^2\) application to build the human skeleton. All joint points information will be transferred by qcOCS\(^3\) to Quartz Composer\(^4\). With Quartz Composer, we implement the game rules: obstacles in front of the players as a target subject, to provide a goal-oriented environment. We render the player’s image with 3D space mapping, allowing us to create a core subject relevant virtual reality graphic effects. We have tested the cycle and found this model to be able to produce immediate graphic response to the player without any latency. All user movements are relayed and reflected immediately on display screen.

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\(^3\)A plugin for Quartz Composer to receive Open Sound Control messages using UDP protocol.

\(^4\)A node-based visual programming language.
### 3.3 Assumption

Several assumptions are needed for this game based learning system design:

1. The sensor is positioned 0.6 - 1.8 meter off the floor, with nothing between player and the sensor.

2. Movements that happened within less than 0.03333 seconds are ignored. According to Guinness World Records in [13], the world fastest martial arts punch is 44 mph (70.8 km/h). Kinect sensor that operates at 30 frames per second can obtain 2 frames for the fastest punch in the world.

3. Due to the limitation of 2D display screen, obstacle will always be displayed in front of the player. In another word, we can make sure the player are always facing (180° parallel) to the display screen and hence player’s hands are always visible to Kinect sensor.

4. The size of the obstacle is of the same the size as punch gloves.

5. Punching gloves is not black in color and is adjustable to fit various size of fist, it will not impact Kinect sensor’s performance.
Chapter 4

Design

4.1 Game Design

We developed a punching game; the game flow is shown in Figure 4.1. We have taken Kiili’s Experiential gaming model [18] into consideration for the system design. We have provided clear goal – hitting obstacle; immediate feedback – real-time display; and challenges – obstacle that run into random directions.

![Game Flow Diagram]

**Overview:** Before the game start, player should stand 1.5 meter from the Kinect sensor and face to the display screen. Game can be started after player’s joint point positions were identified by Kinect sensor. (1 – Punching gloves, 2 – Display screen, 3 – Kinect sensor)

**Start:** Once player were being identified, they will appear on the screen with "fire on fist" graphical effect. They can also see an obstacle which is grey in color in front of them in the display screen. Top left corner of the display will show the number of hit (Number of count start from 0), while top left corner of the screen will show a stopwatch in seconds (Number of seconds start from 0). (4 – Fire on fist, 5 – Obstacle, 6 – Number of hit, 7 – Stopwatch)

**Play:** Obstacle was designed to run into random direction. Sparks are produced when the player has successfully punched the obstacle with his or her hands, indicating successful hit. The number of hit will be increased by 1 for each successful punch. (8 – Sparks on hit)
End: Results will be displayed when the game is over indicating the game has come to an end. The game is over when the number of hit reaches 30. The results are conveyed in the manner of “Congratulations. You did it in XX seconds.”

4.2 Consideration

Taking into consideration of human body physical abilities limitation, we have designed the game short. One is expected to finish the game in less than 60 seconds. Our system rely on 2-dimensional display, hence, the obstacle will always appeared in front of the player in screen projector although the Z coordinates may in fact located behind the player. According to paper [14], video frame rate is an important factor in producing painterly animation. Hence, we have adjusted the motion of obstacle by considering the human visual system that processes 10 to 12 separate images per second. The projection size of the player on display screen is dependent on the distance between player and Kinect sensor, a player appear smaller when they are farther from the Kinect sensor compared to a player who is the same height but located nearer to Kinect sensor. We have designed the obstacle size to be about the same as fist size considering the ideal situation, player is located 1.5 meter from the Kinect sensor.

4.3 Limitation

It is possible for the system to track more than one player with the present technology, however, we have not designed the system to cater for concurrent multiple player. Hence, the system is limited to have one player at a time.

The intention of this design is to promote exercise and indirectly promote martial arts learning. However, the movement are limited to 1 meter in horizontal plane and less than 0.5 meter in vertical plane. The Kinect sensor works perfectly when a player is standing at 1.5 meter in front of it. Hence, forward and backward movements may deteriorate the user tracking and user detection rate.
Chapter 5

Implementation

5.1 System architecture

As a big picture, the player connected wirelessly with our system. The infrared laser projector in Kinect served as a depth sensor to grab the depth data, while the RGB camera captured the image data. The kinect sensor is connected with PC with USB cable. Due to the limitation of small display with portable computer, we have projected the display with a larger screen by connecting the PC and display screen with a display adaptor. All software programs run on the same PC, hence no internet connection is required to run this system at presence. Figure 5.1 shows the high-level architecture presentation of this system.

Figure 5.1: System Architecture
5.2 Hardware and Software

From a hardware perspective, the system consists of a Kinect sensor, a PC, punching gloves and a screen display. From the software perspective, we have utilised the NUI library available in Synapse Application to grab skeleton dataset. The dataset is then sent to Quartz Composer via qcOCS. We managed the logics and game rules in Quartz Composer. As well, we rendered the graphic effects by 3D mapping the skeleton data with the user interface elements.

**Graphic Display:** Real time display as the results of mapping between player’s punch and obstacle position. Sparks graphic effects are produced when the player’s hand position \((x, y)\) matches the obstacle position \((x, y)\), serve as an immediate feedback to a successful hit.

**Kinect:** A sensor to get the depth information and identify the joint points information of the player. These included head, neck, shoulders (right and left), elbows (right and left), hands (right and left), torso, hips (right and left), knees (right and left), feet (right and left).

**Player:** A person needs to be at least 1 meter tall according to Kinect sensor’s requirement in [20]. Kinect sensor will capture the posture of player via geometric data acquisition.

**Punching gloves:** A tool to be attached on player’s fist to create the virtual reality atmosphere in this punching game.

**Synapse [6]:** An application that sends joint points information of the player via Open Sound Control messages to Quartz Composer.

**Quartz Composer:** An application to render graphics using visual programming language. Game logics and rules are applied in Quartz Composer by 3D space mapping between player and graphics.

5.3 Rule and Logic

All the rules and logics of this game design are implemented with Quartz Composer by taking the assumptions in Section 3.3.

1. The 3D narrative space were created by mapping 3D geometric primitives with motion media to produce a floating effects of the obstacle.

2. Particle system patch allowing an image input to be turned into little explosions of dozens of copies of that input. This allowed us to create the explosion effects upon successful punch.

3. A Trackball patch allowing all the faces of a primitive to be viewed as the player “punched” it.

4. Numeric patches such as Conditional, Counter, Logic and Math were utilized to enforce game logics such as Number of hit and Stopwatch in Figure 4.1.
Chapter 6

Evaluation

6.1 Sensor

We have selected Kinect sensor to facilitate this game-based learning system because of the followings:

1 Low-cost range sensor. Kinect sensor is currently selling at $99.99 [21]. It is relatively cheap compared to other available 3D sensors in the market.

2 Wearable sensor always did not really meet the “unobtrusive” requirement. Kinect sensor opens the possibility to track and analyze motion, without any sensors attached to player’s body.

3 Traditional image processing and motion analysis required detailed calculation and complex algorithm. Kinect sensor brought us an opportunity to explore 3D data modeling without the need to know detailed algorithm with reduced computation needed.

4 The ability of Kinect sensor to identity human skeleton joints that make up a tracked skeleton. Body axis is a very important for the study of movement in sports and exercises. [4] Hence, Kinect sensor that could identify 20 joint points information is a very useful body area network device for sports and exercise training.

Kinect sensor consists of a 640 x 480 pixel RGB camera, a 640 x 480 pixel infrared camera, four-microphone sound sensing array and an infrared emitter. We developed a height measurement program in [8] with Xcode utilizing OpenNI framework and NITE middleware to estimate the player’s height by retrieving human joint points coordinates information. The results were promising with 100% detection for user tracking. We noticed the high accuracy but low precision issue due to low depth resolution for far distance with Kinect sensor. However, this issue can be fixed by smoothing filters.

Kinect sensor provided a means of stable communication with PC throughout the evaluation. Unlike conventional sensors, Kinect sensor provided an unobtrusive way of user movement tracking. In a sense, Kinect sensor provided us an opportunity to analyze physical activities efficiently. Hence, we posit that Kinect sensor can be recognized as potential body area network device for sports and exercise.
6.2 Experiment

We have conducted an experiment with this game-based learning system in a Japan University on 6 participants aged between 22 – 26 years old. There is no specific requirement on choosing the participants apart from they have to be at least 1 meter tall and they are fit to perform physical activity with Kinect sensor. We have randomly picked up 6 university students and they were requested to interact with the system twice, once by putting on punching gloves as per Figure 6.1 and once with empty handed. They are being observed during the gameplay in an open space, required to fill in a one-page paper survey and a follow-up interview with authors if necessary.

![Punching gloves](image)

**Figure 6.1: Punching gloves**

All participants were given the same instruction, literally “Please track and punch the stone (obstacle) as many as 30 times within shortest timespan as you can”. All participants have the freedom to choose to play the first game with or without punching gloves and the opposite for the second game. This is to avoid prejudice about punching gloves’ impact on the gameplay. We have prepared a 2 meter square clean space (without chair, table) and shut down all the windows to minimize side or back light that may obstruct Kinect sensor performance.

Figure 6.2 presents the time taken (Note: Measurement in unit of time: Second (s).) to have 30 successful hits on obstacle for 6 participants. The user tracking works perfectly at 100% detection rate. There is a real time feedback on display screen for each user movement and we are excited to find no latency for the communication between Kinect Sensor and PC during the experiments. However, some users required significantly longer detection time than the others. Mainly caused by:

1. Low depth resolution with far distance. It was mentioned in [21] that the random error of depth measurements increases quadratically with increasing distance from the sensor reaches 4 cm at the maximum range.

2. Clothing color appears to have impact on the detection rate. [15] We have difficulty to detect users in black colored shirt.

From figure 6.2 we found that there is slightly faster completion time comparing one playing with gloves and one playing without. The findings revealed that one with punching gloves outperformed himself/herself without punching gloves. While the sequence of playing with or without punching
gloves were in random basis, this clearly shows that the faster completion speed is not related with the sequence of play but the attachment of punching gloves actually improved player performance in this study.

### 6.3 Result

All participants were required to fill up a short survey form that is related to age, score in the game, past experience about martial arts, the impact of punching gloves to their gameplay, did the system make them exercise and did they had fun with this system.

The experiment revealed that punching gloves helped to achieve better performance. This indicates that punching gloves did not limit the movement of players and players can perform better if they have punching gloves attached. Figure 6.3 shows the summary of user survey results. Interestingly, 50% of the participants admitted they felt better to play with punching gloves. It is excited to find out the punching gloves actually possess impact on the experiment results as well as influenced feeling of players gameplay. Provided no technical enhancement on the gloves, players gave the following comments on the gloves:

- *I feel that it was a real exercise when I put on the gloves.*
- *I feel that I am doing real punching when I put on the gloves.*
- *I feel that I am more excited with the game when I put on the gloves.*

All participants agreed that they exercise along with the game. Kinect game is very different from conventional controllers/handheld games. Kinect sensor provides controller-free gaming that brings on full body play, it responds to how player move. In this game, player is required to “hunt down” the obstacle, they have to get off the couch and move their hands to reflect themselves punching obstacle through display. We have designed the obstacle to run in random direction,
hence, one need to move not only their arms, but also the whole body including legs to track the obstacle. A Kinect game can be a good exergaming that bring people out from their couch, move their hands or legs, punch, crouch or even jump!

All participants said they had fun with the game. Players were excited to see the exaggerated effects, fire on fists and sparks effect by Quartz Composer. The authors believe that a successful game based learning system is achieved when the players reached flow state, where they worked hard to play, not in order to get conventional rewards, but because the subject itself was rewarding, fun and pleasurable. We have purposely designed the system to look and feel exactly like an ordinary video game. Slightly different from normal game-based learning systems; we did not include common game mechanics such as achievements, infinite gameplay, levels, lottery, points, status and etc. This finding prove us right where fewer game mechanics did not dilute the fun and pleasure because the gameplay itself is rewarding and meaningful to the player. Gamifying a learning system normally involves creation of the state of flow in player and enhancement of motivation by adding game concepts in existing learning system. However, this is a very hard process, as it does not work by simply adding all game mechanics such as rewards, achievements, game currency and etc into the system without attracting the player to the core subject, let it be maths, science or sports matter. On the other hand, edifying a game system maybe simpler in the sense that adding rules and regulations on top of the game without impacting the harmony of the whole game. As illustrated in experiential gaming model (Figure 2.1), creating challenges is the heart and essence in creating flow. In our system, it is technically possible to have additional rules and tighter regulations for movements and speed can be leverage for different levels by having higher challenges.

We have observed the players throughout both gameplays. We noticed some significant reactions from the players including excitements on their face when they see fire on their hands and the happy laughter face when they have successfully get a score, of course, we saw the disappointing faces when they missed the obstacle too. This matches the results from the survey where everyone said they had fun with the system.
Chapter 7

Discussion

7.1 Enclothed Cognition

The phenomenon of excitement brought by punching gloves may be explained with the term “Enclothed Cognition” to describe the systematic influence that clothes have on the wearer’s psychological processes. Adam & Galinsky in paper [1] argued that the experience of wearing clothes triggers associated abstract concepts and their symbolic meanings. For example, if you wear a white coat that you believe belongs to a doctor, your ability to pay attention may increases sharply. Given the symbolic meaning of the punching gloves as fight, punch, boxing and etc. People who are actually wearing the punching gloves may feel that they have increased ability to punch, this was reflected in the experiment score results. Players scored better when they have attached punching gloves when there is no technical modification or enhancement in the punching gloves itself. We posit that putting on punching gloves may possess similar effects on cognitive processes, like what Adam & Galinsky suggested for clothes.

7.2 Governance with reality tool

On top of the “Enclothed Cognition” effects, we found that punching gloves are as well governing the fist and punching action. In the cases without gloves, we found players played “creatively”, they ignored the given “punch” instructions. They tend to cheat by trying to perform “swipe” instead of ”punch” to get better score, higher achievements in the gameplay. On the other hand, we did not notice this trend of gameplay in the punching gloves gameplays. Instead, they “punch” hardly when they put on punching gloves. Hence, we posit that gaming tools play an important role to governance players to obey game rules and it will be very helpful to have these supportive tools in gameplay for augmented reality effect, to achieve better learning outcomes. This observation outcome may advocate the utilization of reality tool in the future exergame as an alternative way of learning sports.

7.3 Peers competition a good motivation

During observation, we have found something that is not revealed by the survey, which is the intention to replay among the players. There was a situation where a player was requested to fill
in the survey form after he has completed both gameplay. He stayed back to watch the gameplay performed by another player. He has requested a replay in order to outperform another player. This can relate to Kiili’s “The ideation process is most fruitful if it is performed in groups.” The motivation to repeat the same tasks can be improved by introducing peers competition, a list of ranking to invoke goals setting in player’s mindset. As well, the repetition of the same tasks may help to achieve perfect motion in certain sports such as martial arts and dance as practice makes perfect. Hence, game concepts such as ranking list can be a good motivator to encourage replay that may lead to indirect physical training.
Chapter 8

Future Work

In this research, we have obtained several findings that are inspiring and possess the potential to be extended into followings research topics.

8.1 Reality tools for exergame

Encothed Cognition is fairly new established idea and therefore possess a huge research potential. While punching gloves, a wearable tool was discovered to impact players’ cognitive processes in this research, it will be interesting to find out the impact of a non-wearable tool’s psychological impact on the players. The same design model can be applicable to exergame which required non-wearable sports equipments such as baseball, tennis, golf and etc. It will be a stimulant to promote reality tools for exergame if the nature of reality tool as game rules governor is found useful in non-wearable sports equipments.

8.2 Sound and Haptic feedback for virtual reality

During observation, players were generally getting excited to see themselves reflected on display screen with exaggerated effects on fists. The exaggerated effects is not limited to visual, it can be further extended to auditory. For example, sound effect are essentials to accentuating different situations in a movie. In this game, overstate sound effect can be played to indicate the level of power and strength of the player to serve as another indication of immediate feedback.

Lack of reality feedback is one of the very common drawback of modern intangible interaction. Some researchers [25] argued that audio and visual feedback together provide a suitable substitute to haptic feedback. However, user experience can be further enhanced with tactile feedback. Haptic sensors on tools such as gloves or clothings may serve as a good way to mimic the force feedback in real world to stimulate the tactile sensation of human being.

8.3 Game concepts to boost up training

Motivation is found to be very important to keep player return to gameplay. It was already known that the most important intrinsic motivation to be the subject itself, it has to be rewarding, fun and pleasurable. However, we found that peer competition is one of the very attractive extrinsic
motivation to exergame’s player in the observation. Stephan mentioned in his book [29], “you can think of these ideas as all the different ingredients in the kitchen: paprika, celery, chocolate chips, cheese, salt, brown sugar, tomatoes. You wouldn’t grab all of these ingredients and throw them in a bowl. Neither should you grab a handful of these principles and throw them at your project.” Hence, it is crucial to examine each game concept individually in the game instead of throwing all game concepts into an exergame regardless it’s efficiency to keep players motivated.
Chapter 9

Conclusion

This dissertation presented a prototype to unobtrusively teach player about martial arts via game-based learning system. The authors believe that a successful game based learning system is achieved when the players reached flow state. Hence, the key point to the success of this system will be a core subject that is rewarding, fun and pleasurable. The main point is to get players to have fun doing something, if possible, learn something from it.

The results revealed that Kinect sensor’s user detection rate was promising. It’s no latency feature and high accuracy detection rate, on top of it’s controller-less feature to replace wearable sensors convinced us that Kinect sensor is a very useful body area network device for physical game-based learning, training or exergame. We foresee it’s importance and potential huge contribution to physical game based learning system with its easy setup inherent quality.

We have posited another plausible way of designing game based-learning system. Instead of mimicking game by gamifying an existing learning system with complex game mechanics, we proposed the other way round, which is edifying an existing game system by adding in education elements. It can be done by add-on rules and learning concepts as part of the challenges in game model. The same design model can be extended and apply to other sports such as tennis, golf, basketball, baseball and etc. In fact, it’s not limited to sports only. Kinect sensor’s ability to accurately extract human body joint points information can be applied to all type of activities that emphasize on posture and body axis.

The “Enclothed Cognition” effects from the punching gloves have exceeded our expectations. Provided, punching gloves did not bring negative impact to Kinect sensor’s performance, never cause latency into the system and did not bring confusion to the players. We posit that bringing real-world tools such as real golf club, real racquet, baseball bat and etc into game will boost up the augmented reality effect as well as triggers associated abstract concepts and their symbolic meanings to the players. This can potentially enhance the game experience as well as boost the learning values in a game.

We hope that more edified games will be available in the future, and one who scored perfect in the virtual tennis game can score well too in a real tennis match.
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