Quantifying Engagement of Electronic Sports and Cultural Aspects on Game Market

By Xiong Shuo

A thesis submitted to
School of Information Science,
Japan Advanced Institute of Science and Technology,
in partial fulfillment of the requirements
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Master of Information Science
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Written under the direction of
Professor Hiroyuki Iida

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Professor Hiroyuki Iida
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Chapter 1

Introduction

Games came into the world together with the advent of tools. Over 5500 years ago Senet was played in Pre-dynastic Egypt, as evidenced by its inclusion in burial sites. Until now the four most-popular classic board games have been Go, Chess, Xiangqi and Shogi. Except for Go, in researching the various pieces of Chess, Xiangqi and Shogi, we can find some similar points. For example, the knights (horse) all move in an L shaped fashion. According to some research, the Indian game Chaturanga identifies as the ancestor of Xiangqi, Shogi and Chess. The game of Go or "Weiqi" in Chinese, enjoys a special place in board game history. Not only is it one of the oldest games known, it has kept essentially the same rules for longer than any other board game. After its origins in China perhaps as far back as 2300 B.C, Go spread into Korea in the second century, and finally traveled to Japan via trade routes sometime around the year 700 A.D.

Until today, game not only limit on board game or card game. In fact, "game" is a very broad concept which include body sports, brain sports and modern video games. All the human activity which contain competition element can be defined as game, even commercial activity, political struggle and real warfare.

According to the game information situation, process and form, we divide all the games into four types, every area has the corresponding mathematical research model. In this thesis, our research mainly focus on the video game– StarCraft II, and a new mathematical method will be guided.

Game informatics is a new research area in the field of information and computer science. Except for Japan, almost all the players around the world have used the personal computer to play games. Therefore, in the future, we need to pay more attention on this new research branch. In this article, we will focus on the game refinement theory and a worldwide famous video game StarCraft II, which is a real time strategy game, to present the several research achievement.

In our thesis, the research is divided into two directions, nature science part and society science part. From Chapter 2 to Chapter 4, the nature science part that will be presented is the research of my master course in JAIST, and Chapter 5 will present the content about society problem as an independent research topic.

For the nature science part, almost the research method and idea are all based on the game refinement theory, which is created by Professor Hiroyuki Iida. Game refinement

idea is a unique theory that has been supported to an proposed based on the uncertainty of game outcome. A game refinement measure was derived from the game information progress model and had been applied in the traditional board games. The present challenge is to apply the game refinement theory in the domain of various games such as RTS (StarCraft II), MOBA (DotA), crane game and score limited game. To do so, we use StarCraft II as a testbed and introduce a concept of strategy tree in order to construct a game tree of a RTS game. Then, game refinement values are calculated and compared with other type of games. It is found that StarCraft II has a zone value of game refinement.

Starcraft II is a real-time strategy game where players have the goal to destroy their enemy by building a base and an army. Players can choose 1 out of 3 races to play with. These races are Terran, Protoss, and Zerg. The Terran is humans, the Protoss are alien humanoids with highly advanced technology, and the Zerg is a collection of assimilated creatures who use biological adaptation instead of technology. For anything that the player want to build, he needs to gather two types of resources: minerals and gas. These resources are used to construct buildings, which in turn can be used to produce units. At the start of the game, not all units and buildings are available. New construction options can be unlocked by making certain buildings. This means that some units and buildings are available at the start of the game while others become available later in the game.

In order to play the game well, the player must engage in strategy, macro-management and micro-operation. Strategy determines whether player can establish the strategic superiority. Macro-management determines the economic strength of a player. Micro-operation determines how well a player is able to locally control small groups and individual units. This includes movements and attacks that are issued by the player. In addition, we notice in the StarCraft II, the most interesting part is the opening stage, because in this time domain, strategy element is the most important element and highly similar as traditional board game. So all of the research achievements of StarCraft II in our thesis are based on the opening strategy.

In order to establish the channel between traditional board game and real time strategy game, we create a new concept which is called strategy tree. In the traditional board game, minimax tree is a decision rule used in decision theory, game theory, statistics and philosophy for minimizing the possible loss for a worst case (maximum loss) scenario. Originally formulated for two-player zero-sum game theory, covering both the cases where players take alternate moves and those where they make simultaneous moves, it has also been extended to more complex games and to general decision making in the presence of uncertainty. Since Starcraft II is an incomplete information game, all the players do not know their opponent's condition, so they only consider about their own tree. As we know, while we want to execute a strategy, we need some premises. Taking Shogi as an example, Ibisha is the father node of Yagura. According to this idea, we can establish the strategy tree of Starcraft II and other real time strategy game. The most prominent feature of strategy tree in real time strategy game is the unbalance tree. As we know, in traditional board game, all of the rules are based on the step by step, so for each player, the branch length from strategy children nodes to their father node is always equal to

one. However, in StarCraft II or other real time strategy game, the depth is defined by steps process, we notice that the children node may have different depth from their father nodes. Therefore, we consider one method to solve it, that is to change the unbalance depth tree into the balance tree, then lead a new concept temporary node to solve the model and then analyze the game refinement value of StarCraft II.

Later, this thesis makes contribution to apply game refinement theory in these new areas and supports the effectiveness of game refinement theory. For the crane game application, experiments have been conducted by observing games of players in two countries: Japan and Thailand. The results show that Japanese crane games are more engaging. We will discuss some key factors in respect of types of machines and also the emotional impact. For the DotA application, we evaluate the measurement for different versions of DotA. The results of game refinement value show that DotA has an appropriate value similar as the board games and sports games. Similar as real sports seesaw game, fighting game is a video game genre in which a player controls an on-screen character and engages in close combat with an opponent. These characters tend to be of equal power and they will fight matches consisting of several rounds, which take place in an arena. This theory can be widely applied to various types of game to assess the entertainment impact of target games.

As for the video game "StarCraft II", we also have some achievement in society science domain. Japanese do not know about StarCraft II or other Real Time Strategy game and MOBA game when they are asked. Besides the nature science part about game refinement theory and opening strategy, we should also pay attention on the society part and then find out why Japanese market and players have not accepted the Western game, from this point to analyze the macroscopic problem between Japan and China game market. In ancient times, classic board games developed and dispersed throughout all the world. However, in recent years the game industry is developing fast in many countries. Japanese games and Chinese games all have similar opportunities and problems in the modern context. The most serious problem facing both is "sakoku", seclusion from the outside world. Although the effects of sakoku are very far-reaching, we look at the effects of seclusion from the outside world on game development. The Chinese game industry is in the development period and the Japanese game industry is in its heyday. If the sakoku problem is not to be solved, we predict the Japanese game industry will decline and fall behind that of the West. Some genius Japanese game designers such as Kojima Hideo and Inafune Keji have already said as much. For their part, Chinese developers who fail to address gamers beyond their borders stand to lose the best chance to step into the development of the gaming future.

Chapter 2

Research Background

In this Chapter, we present our study of the thesis back ground. Section 2.1 presents the classification of all the game. Section 2.2 presents the introduction of Real time strategy game. Section 2.3 presents the main research object with StarCraft II.

2.1 Four Game Types

According to the information situation and game process dynamic stable, we can divide all the games into four types. As the Figure 2.1 shows.

First is Non-random complete information game, such as Chess, Go, Chinese chess and Shogi, every player can see all the information then to do the judgement, in the other hand, all the players have the stable and equal power, most of the traditional research and mathematical model focus on this part.

Second one is Random complete information game, such Monopoly or dice game, although all the players can know any information, they cannot control or predicate what will happen, so we call the game process belong to random state.

Third type is Random incomplete information game such as Poker and Mahjongg, players do not know their opponent situation, and also they cannot control their next step, still a lot of research pay attention to these area.

Final one is our topic— Non-random incomplete information game, players hardly know their opponent's information, but in every step or in every time point, a mature player can predicate what is happening or what will happen, then he can choose or adapt his strategy against the opponent, the traditional Non-random incomplete information game almost belong to turn-based game, just like Dark chess, but in this age, by the development of computer. A new type of Non-random incomplete information game born out, we call them real-time strategy game, every step are all happening in the same time for each player. In fact, the real world warfare is a typical Non-random incomplete information "game".

The Chinese military philosopher Sun Wu (BC545 to BC470) had written a very famous theory in his book: "If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself but not the enemy, for every victory

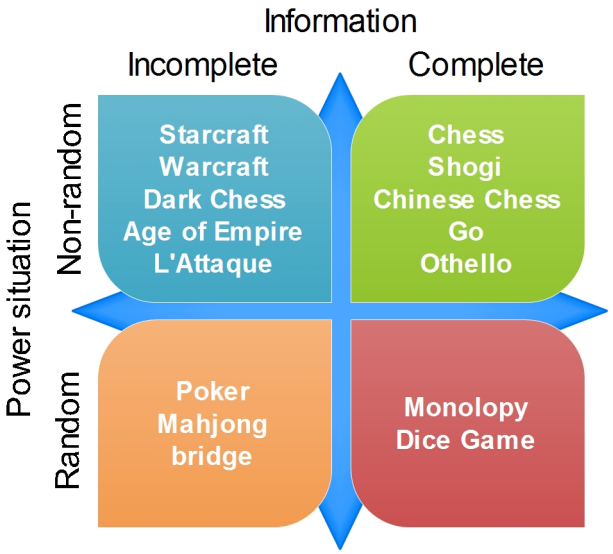

Figure 2.1: Four-quadrant game type

gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle" (The Art of War). So how we establish information advantage in incomplete information game is a very important and serious research topic.

In this thesis, my research have created and established a lot of new ideas, new methods and new mathematical model in Non-random incomplete information game area. StarCraft II is one of the typical one of them. Also, in the chapter 5, we will analyze some current problem of Japan game market.

2.2 Real Time Strategy Game

Real-time strategy (RTS) is a sub-genre of strategy video games which does not progress incrementally in turns. In an RTS, as in other wargames, the participants position and maneuver units and structures under their control to secure areas of the map and/or destroy their opponents' assets. In a typical RTS, it is possible to create additional units and structures during the course of a game. This is generally limited by a requirement to expend accumulated resources. These resources are in turn garnered by controlling special points on the map and/or possessing certain types of units and structures devoted to this purpose. More specifically, the typical game of the RTS genre features resource gathering, base building, in-game technological development and indirect control of units.[1]

The tasks a player must perform to succeed at an RTS can be very demanding, and complex user interfaces have evolved to cope with the challenge. Some features have been borrowed from desktop environments; for example, the technique of "clicking and dragging" to select all units under a given area.

Though some game genres share conceptual and gameplay similarities with the RTS

template, recognized genres are generally not subsumed as RTS games. For instance, city-building games, construction and management simulations, and games of the real-time tactics variety are generally not considered to be "real-time strategy".

In a typical real-time strategy game, the screen is divided into a map area displaying the game world and terrain, units, and buildings, and an interface overlay containing command and production controls and often a "radar" or "minimap" overview of the entire map. The player is usually given an isometric perspective of the world, or a free-roaming camera from an aerial viewpoint for modern 3D games. Players mainly scroll the screen and issue commands with the mouse, and may also use keyboard shortcuts.

In most real-time strategy games, especially the earliest ones, the gameplay is generally fast-paced and requires very quick reflexes. For this reason, the amount of violence in some games makes RTS games close to action games in terms of gameplay.

Gameplay generally consists of the player being positioned somewhere in the map with a few units or a building that is capable of building other units/buildings. Often, but not always, the player must build specific structures to unlock more advanced units in the tech tree. Often, but not always, RTS games require the player to build an army (ranging from small squads of no more than 2 units, to literally hundreds of units) and using them to either defend themselves from a virtual form of Human wave attack or to eliminate enemies who possess bases with unit production capacities of their own. Occasionally, RTS games will have a preset number of units for the player to control and do not allow building of additional ones.

Resource gathering is commonly the main focus of the RTS games, but other titles of the genre place higher gameplay significance to the how units are used in combat, the extreme example of which are games of the real-time tactical genre. Some titles impose a ceiling on the number simultaneous troops, which becomes a key gameplay consideration, a significant example being StarCraft, while other titles have no such unit cap.[1]

2.2.1 Micromanagement and macromanagement

Micromanagement refers to when a player's attention is directed more toward the management and maintenance of his or her own individual units and resources. This creates an atmosphere in which the interaction of the player is constantly needed. On the other hand, macromanagement refers to when a player's focus is directed more toward economic development and large-scale strategic maneuvering, allowing time to think and consider possible solutions. Micromanagement frequently involves the use of combat tactics. Macromanagement tends to look to the future of the game whereas Micromanagement tends to the present.[1]

2.2.2 Criticism of gameplay

Because of their generally faster-paced nature (and in some cases a smaller learning curve), real-time strategy games have surpassed the popularity of turn-based strategy computer games. In the past, a common criticism was to regard real-time strategy games as "cheap imitations" of turn-based strategy games, arguing that real-time strategy games

had a tendency to devolve into "click-fests" in which the player who was faster with the mouse generally won, because they could give orders to their units at a faster rate. The common retort is that success involves not just fast clicking, but also the ability to make sound decisions under time pressure. The "clickfest" argument is also often voiced alongside a "button babysitting" criticism, which pointed out that a great deal of game time is spent either waiting and watching for the next time a production button could be clicked, or rapidly alternating between different units and buildings, clicking their respective button.[1]

A third common criticism is that real-time gameplay often degenerates into "rushes" where the players try to gain the advantage and subsequently defeat the opponent as quickly in the game as possible, preferably before the opposition is capable of successfully reacting. For example, the original Command & Conquer gave birth to the now-common "tank rush" tactic, where the game outcome is often decided very early on by one player gaining an initial advantage in resources and producing large amounts of a relatively powerful but still quite cheap unitwhich is thrown at the opposition before they have had time to establish defenses or production. Although this strategy has been criticized for encouraging overwhelming force over strategy and tactics, defenders of the strategy argue that they are simply taking advantage of the strategies utilized, and some argue that it is a realistic representation of warfare. One of the most infamous versions of a rush is the "Zergling rush" from the real-time strategy game StarCraft; in fact, the term "zerging" has become synonymous with rushing.[1]

2.2.3 Tactics vs. strategy

Real-time strategy games have been criticized for an overabundance of tactical considerations when compared to the amount of strategic gameplay found in such games. In general terms, military strategy refers to the use of a broad arsenal of weapons including diplomatic, informational, military, and economic resources, whereas military tactics is more concerned with short-term goals such as winning an individual battle. In the context of strategy video games, however, the difference is often reduced to the more limited criteria of either a presence or absence of base building and unit production.[1]

2.3 StarCraft II

2.3.1 The introduction of research object

Our research mainly focus on Starcraft II: Heart of the Swarm(A expansion of starcraft II). It is a most outstanding and popular real time strategy game where the players goal is to destroy their enemys base by developing their own base and an army. Players can choose from three different races (Terran, Zerg, Protoss) to play, each of which plays very differently. To construct buildings and produce army units, a player needs minerals and gas. During the game, players unlock new options by constructing particular buildings. The battlefield and game UI as the Figure 2.2 shows

Figure 2.2: The battlefield of StarCtaft II

The game revolves around three species: the Terrans, human exiles from Earth, as the Figure 2.3 shows; the Zerg, a super-species of assimilated life forms, as the Figure 2.4 shows; and the Protoss, a technologically advanced species with vast mental powers, as the Figure 2.5 shows.

Figure 2.3: The concept of Terran

In macroscopic view, three races are the same strength, however in microcosmic view every race has their own advantage and disadvantage what is quietly related with game refinement. In the Table 2.1 have introduced the character of three races.[13]

Figure 2.4: The concept of Zerg

Figure 2.5: The concept of Protoss

2.3.2 The research goal and target

Video games grow more popular every year and Real Time Strategy (RTS) is a sub-genre of strategy video games which does not progress incrementally in turns [4][3]. Our

Table 2.1: The features of three races

Race	Features
Terran	1. Excellent defensive ability in Opening 2. The are many strategies in Opening, however with the time past, that will decline 3. Endurance is weak 4. From quantitative change to qualitative change 5. Observe weakly in Opening, however with the time past, that will develop
Zerg	1. Strength in numbers 2. The opening strategy is less than Terran and Protoss, but with the time past, that will develop fast 3. Endurance is strong 4. Observe is normal in any time
Protoss	1. High quality of soldiers 2. The are many strategies in Opening, however with the time past, the number of strategy will decline 3. Observe is very weak in Opening, however with the time past, that will develop up to normal level 4. Endurance is normal

research interest is to know a theoretical aspect of attractiveness of such popular video games. However, any method or approach to measure the engagement of target games is strictly limited. In other words, no mathematical theory has been established in this direction. The present study is the first attempt to explore the attractiveness of RTS using a new game theory which focuses on the game sophistication.

Many efforts have been devoted to the study of strategic decision making in the framework of game theory with focus on mathematical models of conflict and cooperation between intelligent rational decision-makers or game-players. Game theory originated in the idea regarding the existence of mixed-strategy equilibrium in two-person zero-sum games [7], which has been widely recognized as a useful tool in many fields such as economics, political science, psychology, logic and biology.

However, little is known about mathematical theory from the game creator's point of view. An early work in this direction has been done by Iida *et al.* [5][6], in which a measure of game refinement was proposed based on the concept of game outcome uncertainty. A logistic model was constructed in the framework of game-refinement theory and applied to many board games including chess variants. Recently a general model of game refinement was proposed based on the concept of game progress and game information progress [11]. It bridges a gap between board games such as chess and sports games such as soccer. The next challenge is to apply the game refinement theory to RTS games

In this study we have chosen the domain of StarCraft II, which is one of the most popular RTS games. We analyze the attractiveness of StarCraft II based on the game refinement theory. In typical RTS games like StarCraft II, players build armies and vie

for control of the battlefield. The armies in play can be as small as a single squad of Marines or as large as a full-blown planetary invasion force. As commander, one observes the battlefield from a top-down perspective and issue orders to one's own units in real time. Strategic thinking is key to success. Players need to gather information about the opponents, anticipate their moves, outflank their attacks, and formulate a winning strategy. StarCraft II features three distinct races whose armies comprise entirely unique units and structures. Each race has its own strengths and weaknesses, and knowing their tactical profiles can mean the difference between glorious victory or crushing defeat.

To our best knowledge, no one published any successful application of the game refinement theory to RTS games. The main reason is that a RTS game is basically time-continuous, so any method to determine the game progress has not yet been established. In this study we propose an idea to determine the game progress of RTS games bases on a concept of strategy tree.

Chapter 3

Attractiveness of Real Time Strategy Games

The contents of this chapter has been published in:
Shuo XIONG, H. Iida (2014). Attractiveness of Real Time Strategy Games, International Conference on Systems and Informatics (ICSAI 2014), IEEE, pages 264-269.

3.1 Introduction

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In Section 3.2 we present the game refinement theory. Then, a concept of strategy tree will be described in Section 3.3 while showing how to apply the strategy tree to StarCraft II. Section 3.4 presents an application of game refinement theory to StarCraft II. Finally, concluding remarks are given in Section 3.5.

3.2 Game Refinement Theory

We give a short sketch of the basic idea of game refinement theory from [11]. The "game progress" is twofold. One is game speed or scoring rate, while another one is game information progress with focus on the game outcome. In sports games such as soccer and basketball, the scoring rate is calculated by two factors: (1) goal, i.e., total score and (2) time or steps to achieve the goal. Thus, the game speed is given by average number of successful shoots divided by average number of shoot attempts. For other score-limited sports games such as Volleyball and Tennis in which the goal (i.e., score to win) is set in advance, the average number of total points per game may correspond to the steps to achieve the goal [12].

Game information progress presents the degree of certainty of a games results in time or in steps. Let G and T be the average number of successful shots and the average number of shots per game, respectively. Having full information of the game progress, i.e. after its conclusion, game progress $x(t)$ will be given as a linear function of time t with $0 \leq t \leq T$ and $0 \leq x(t) \leq G$, as shown in Equation (4.5).

$$x(t) = \frac{G}{T}\, t \tag{3.1}$$

However, the game information progress given by Equation (4.5) is unknown during the in-game period. The presence of uncertainty during the game, often until the final moments of a game, reasonably renders game progress as exponential. Hence, a realistic model of game information progress is given by Equation (4.2).

$$x(t) = G(\frac{t}{T})^n \tag{3.2}$$

Here n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Equation (4.2) twice. Solving it at $t = T$, the equation becomes

$$x''(T) = \frac{Gn(n-1)}{T^n}t^{n-2} = \frac{G}{T^2}n(n-1)$$

It is assumed in the current model that game information progress in any type of game is encoded and transported in our brains. We do not yet know about the physics of information in the brain, but it is likely that the acceleration of information progress is related to the forces and laws of physics. Hence, it is reasonably expected that the larger the value $\frac{G}{T^2}$ is, the more the game becomes exciting due to the uncertainty of game outcome. Thus, we use its root square, $\frac{\sqrt{G}}{T}$, as a game refinement measure for the game under consideration. We can call it R value for short.

Here we consider the gap between board games and sports games by deriving a formula to calculate the game information progress of board games. Let B and D be average branching factor (number of possible options) and game length (depth of whole game tree), respectively. One round in board games can be illustrated as decision tree. At each depth of the game tree, one will choose a move and the game will progress. Figure 4.1 illustrates one level of game tree. The distance d, which has been shown in Figure 4.1, can be found by using simple Pythagoras theorem, thus resulting in $d = \sqrt{\Delta l^2 + 1}$.

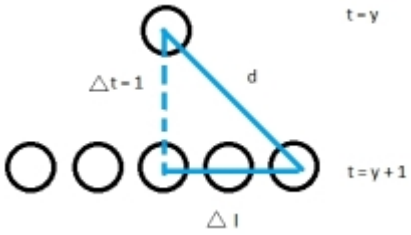

Figure 3.1: Illustration of one level of game tree

Assuming that the approximate value of horizontal difference between nodes is $\frac{B}{2}$, then we can make a substitution and get $d = \sqrt{(\frac{B}{2})^2 + 1}$. The game progress for one game is the total level of game tree times d. For the meantime, we do not consider Δt^2 because the value ($\Delta t^2 = 1$) is assumed to be much smaller compared to B. The game length will be normalized by the average game length D, then the game progress $x(t)$ is given by $x(t) = \frac{t}{D} \cdot d = \frac{t}{D}\sqrt{(\frac{B}{2})^2} = \frac{Bt}{2D}$. Then, in general we have, $x(t) = c\frac{B}{D}t$, where c is a different constant which depends on the game considered. However, we manage to explain how to obtain the game information progress value itself. The game progress in the domain of board games forms a linear graph with the maximum value $x(t)$ of B. Assuming $c = 1$, then we have a realistic game progress model for board games, which is given by

Table 3.1: Measures of game refinement for board games and sports games

Game	B or G	D or T	R
Chess	35	80	0.074
Go	250	208	0.076
Basketball	36.38	82.01	0.073
Soccer	2.64	22	0.073

$$x(t) = B(\frac{t}{D})^n. \tag{3.3}$$

Equation (4.3) shows that the game progress in board games corresponds to that of sports games as shown in Equation (4.2).

To support the effectiveness of proposed game refinement measures, some data of games such as Chess and Go [5] from board games and two sports games [11] are compared. We show, in Table 3.1, a comparison of game refinement measures for various type of games. From Table 3.1, we see that sophisticated games have a common factor (i.e., same degree of acceleration value) to feel engagement or excitement regardless of different type of games.

3.3 Strategy Tree and RTS

Our present study focuses on StarCraft II which is a RTS game where the player's goal is to destroy their enemy's base by developing their own base and an army. In StarCraft II players cannot see their opponent's situation and they have the same power, StarCraft II does not rely on any chance. Therefore, in a sense this game is similar with board games such as chess. It means that we can use some similar tools or methods to analyze the game of StarCraft II.

3.3.1 Basic Idea of Strategy Tree

Minimax strategy is a decision rule used in decision theory, game theory, statistics and philosophy for minimizing the possible loss for a worst case (maximum loss) scenario [9]. Alternatively, it can be thought of as maximizing the minimum gain (maximin or MaxMin). Originally formulated for two-player zero-sum game theory, covering both the cases where players take alternate moves and those where they make simultaneous moves. It has also been extended to more complex games and to general decision making in the presence of uncertainty. The traditional minimax tree is illustrated in Figure 3.2. Because StarCraft II is an incomplete information game, neither player A or player B do not know opponent's condition, so they only consider about their own tree.

Our idea is to combine the search tree of both players. Then we can establish a strategy tree of StarCraft II.

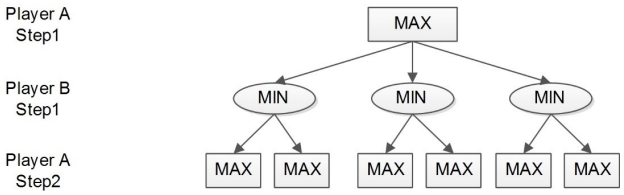

Figure 3.2: The traditional minimax tree

3.3.2 Strategy Tree of StarCraft II

StarCraft II is a RTS game where players have the goal to destroy their enemy by building a base and an army. Players can choose 1 out of 3 races to play with. These races are: Terran, Protoss, and Zerg. Terran are humans, Protoss are alien humanoids with highly advanced technology, and Zerg are a collection of assimilated creatures who use biological adaptation instead of technology [2].

For anything a player builds, he needs to gather 2 types of resources: minerals and gas. These resources are used to construct buildings which in turn can be used to produce units. At the start of the game, no all units and buildings are available. New construction options can be unlocked by making certain buildings. This means that some units and buildings are available at the start of the game while others become available later in the game. This is also called tier: the point in time that certain units and buildings become available.

In order to play the game well, one must engage in strategy, macro-management and micro-operation. Strategy determines whether player can establish the strategic superiority. Macro-management determines the economic strength of a player. This is determined by the construction of buildings, the gathering of resources and the composition of units. Micro-operation determines how well a player is able to locally control small groups and individual units. It includes movements and attacks that are issued by the player [13].

Macro-management of a player heavily depends on the strategy the player has chosen to follow. For example, if a player chooses to rush his opponent by making fighting units at the very early stage in the game, his economy will suffer. On the other hand, if a player chooses to focus on having a strong economy before building an adequate-size army, he would take the risk of being overrun by his opponent.

Opening stage of StarCraft II

According to the game features of StarCraft II, we should divide the game into four parts: Opening, Mid-prophase, Mid-anaphase and Endgame. The game could finish in any time domain. For example, while players choose supervise attack or extremely rush strategy, the game must finish in 7 or 8 minutes or before; Normally, the average game time is 15 to 20 minutes (it means that most games will not enter into Mid-anaphase or Endgame time domain). As our experience, we find the game in different time domain, the **main elements** are completely disparate.

Table 3.2: Feature of Starcraft II in every process

Domain	Timing	Character
Opening	0 to 10 minutes	Strategy
Mid-prophase	10 to 20 minutes	Economy and Management
Mid-anaphase	20 to 30 minutes	Economy and Operation
Endgame	Over 30 minutes	operation

In the opening, the StarCraft II is similar to real war or traditional board games. In other words, only in the opening time domain, StarCraft II is an intellectual game. While a game enters into Mid-prophase or Mid-anaphase, the main elements are economy, management and operation. It means that in mid-game, the StarCraft II is similar to the simulation game. As we know, a good chess player not always can be a good manager, a strategy genius does not mean that he could be a nice executive.

For the endgame, the operation element will be more and more important, even occupy all the StarCraft II process. It means that on that time StarCraft II is similar to Super Mario. When we watch somebody playing Super Mario, we rarely focus on his intellectual strategy, we only focus on whether or not his operation skill is proficient. In this situation, StarCraft II is like sports games such as soccer and basketball.

Figure 3.3: Feature of StarCraft II

According to the above, only in the opening stage, we have the strategy tree, and then find the B and D. Also in the opening stage, the game is highly similar to traditional board games or brain sports, we can take example by game tree model to establish new mathematical model. If we want to research mid-game or end game, we must find other model or method. At least, the meaning of B and D must be changed. Actually, the completion between profession players, the most exciting and wonderful part is mid-game. It is likely that body sports are more suitable than brain sports to watch. However for AI research, apparently opening part seems more valuable. Also the opening stage is worth to establish opening book or do other related research in the future. So these are the reasons why we only focus on the opening stage.

Strategy Tree – The Tree with Unbalanced Children Nodes

In StarCraft II, there are three races. Every race has their own particular strategy tree. Here we analyze the Protoss strategy tree. We enumerate all the opening strategies existed, which are commonly used in High Ladder system. Professional players have validated their rationality through experience and experiments.

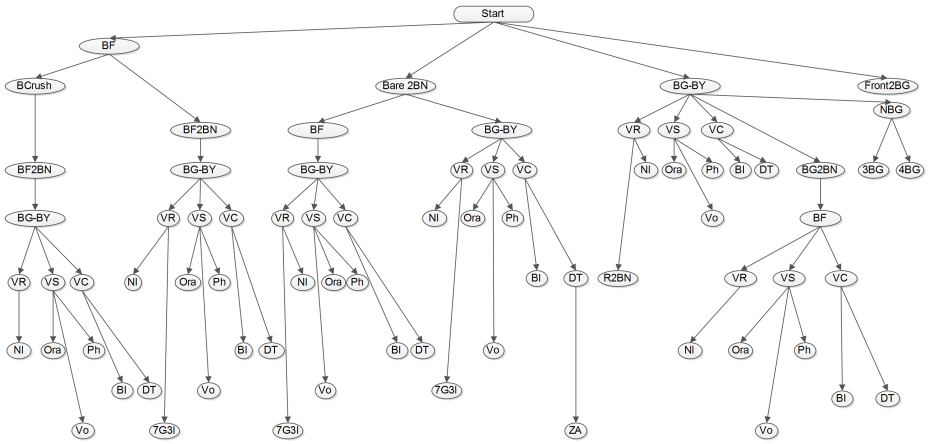

Figure 3.4: The opening strategy tree of Protoss

In the following strategy tree, the content is denoted as "4BG" or "BF" which means a strategy name or code name. These strategies would be used in the opening stage, i.e., within 10 minutes after starting a game. Then we get the strategy tree as shown in Figure 3.4.

Since StarCraft II is a RTS game, its minimax tree cannot be built in a normal way. For example, the depth of tree is defined by each step or turn, while in Starcraft II, the depth might be given by time evolution. We show, in Figure 4.4, such an example. In Figure 4.4, we notice that the child node "BCrush" and child node "BF 2BN" have the different depth. This situation would never happen in traditional board games to build a minimax search tree. So we consider one method to solve it, while changing an unbalance depth tree into a balance tree. While adding the temporary node, then we get another strategy tree of Protoss as shown in Figure 3.6.

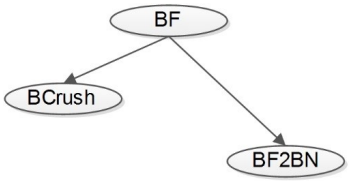

Figure 3.5: An example of strategy tree with two unbalanced child nodes

3.4 Analysis of Attractiveness of StarCraft II

3.4.1 Applying Game Refinement Measure

The game of StarCraft II can be divided into four parts. For the artificial intelligence, the most important part is the opening domain where players have to focus on their strategies.

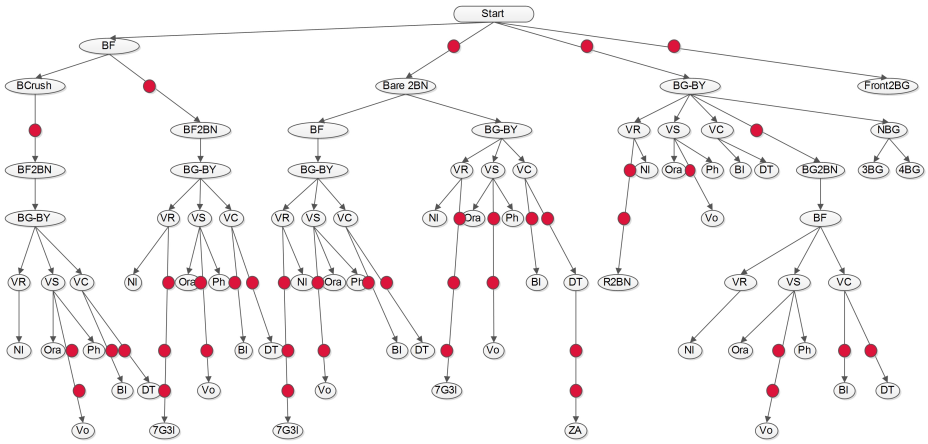

Figure 3.6: The new opening strategy tree of Protoss with temporary node

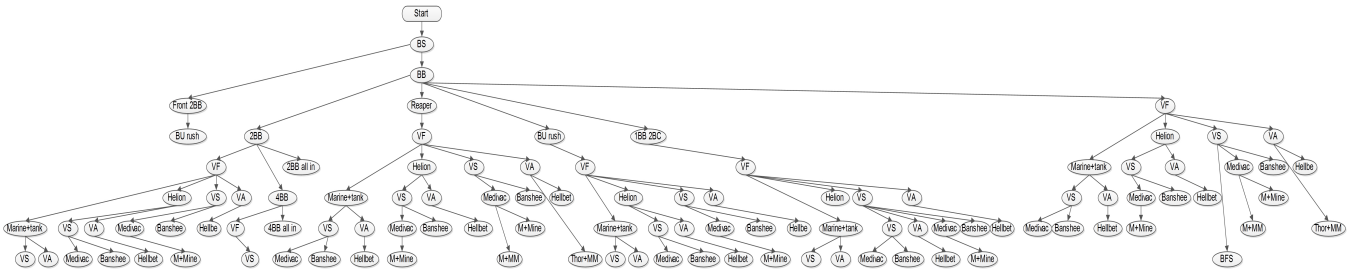

Figure 3.7: The opening strategy tree of Terran

In this area, the weaker player would have a little chance to win. Now we can draw the figure of Terran and Zerg as follows.

In Figure 3.6, the Protoss tree's depth is 9. In this tree, the total branching factor is 116 and we have 74 parent nodes, so average branching factor is $B = \frac{116}{74} = 1.57$. However, until now we cannot calculate the game refinement value directly. Because in the real game, two players cannot maintain playing game independently at anytime. Sometimes, they will use spy and predict their opponent's choice to modify their strategy. So we can combine two trees into one tree, as shown in the following figure.

For the combined strategy tree, player A's choice and Player B's choice are all happened in the same time. No matter player A choose A1 or A2, it will not affect player B to decide B1, B2 or B3, combine the two trees together, can analyze the game refinement value more accurately. While player A uses spy then realize player B will choose "some strategy", he can modify his next path based on player B's parent node.

In minimax tree, the whole tree size is estimated by B^D, and the game refinement formula equal to $\frac{\sqrt{B}}{D}$, while in the combined strategy tree, the tree size is $(B^2)^D$, so the game refinement value should be given by $\frac{\sqrt{B}}{2D}$. Then the game refinement value of Protoss in the opening time domain is given by

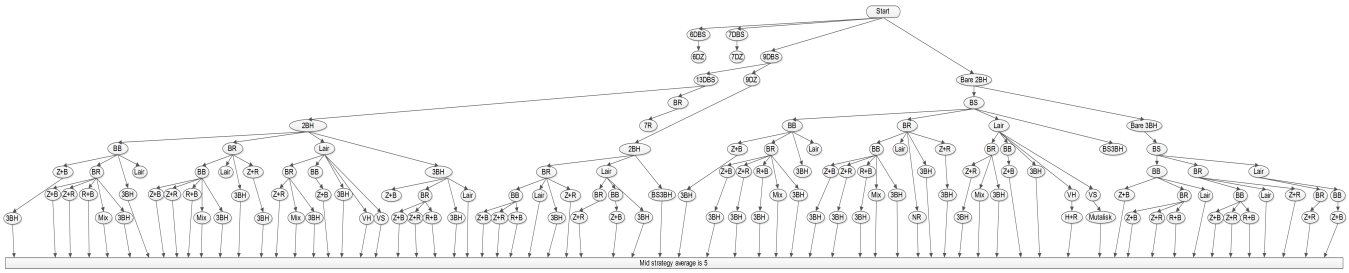

Figure 3.8: The opening strategy tree of Zerg

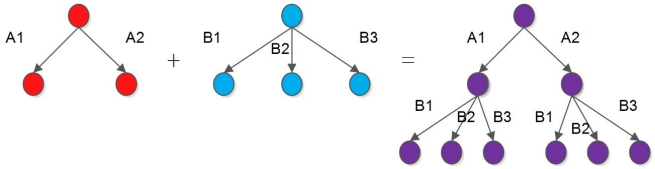

Figure 3.9: Combination of two strategy trees

$$R = \frac{\sqrt{B}}{2D} = \frac{\sqrt{1.57}}{2 * 9} = 0.0695.$$

Similarly, race Terran and Zerg also have their own strategy tree, then the game refinement value is calculated, as shown in Table 4.6. In this table, we notice that Zerg has two game refinement values.

Table 3.3: Measure of game refinement for three races in Starcraft II

Race	all nodes	all parent nodes	B	D	R-value
Terran	126	76	1.64	16	0.0805
Zerg	219	141	1.54	18	0.0692
Zerg*	564	210	1.61	20	0.0819
Protoss	116	74	1.55	18	0.0691

The R-value not only means the property of every race, but also means the competition between same race such as Terran versus Terran or Zerg versus Zerg. We evolve the mathematical formula in Equation (3.4).

$$R = \frac{\sqrt[4]{\frac{AllBranchFact_1}{AllFatherNode_1} * \frac{AllBranchFact_2}{AllFatherNode_2}}}{\log_{Avg.depth}(depth_1 * depth_2) * Avg.depth} \tag{3.4}$$

Then we have the full data of every race's competition in Table 3.4:
Compared with other traditional board games, the result are closed, as Table 3.5 shows:

Table 3.4: Measure of game refinement for every competition in Starcraft II

	Terran	Zerg	Zerg*	Protoss	Average
Terran	0.0805	0.0746	0.0809	0.0747	0.07675
Zerg	0.0746	0.0692	None	0.0694	0.07107
Zerg*	0.0809	None	0.0819	0.0754	0.07940
Protoss	0.0747	0.0694	0.0754	0.0691	0.72150

Table 3.5: Game refinement values for StarCraft II and board games

Game	$\frac{\sqrt{B}}{D}$
Chess	0.074
Go	0.076
Terran	0.07675
Zerg	0.07107 to 0.07940
Protoss	0.72150

3.4.2 Discussion

As shown in Figure 3.7 and Figure 3.8, strategy trees of Terran and Zerg are more complex than Protoss. In particular Zerg's strategy tree has critical points, as shown in Figure 3.8. This means that game refinement value will change after crossing the critical point [13].

Below we show the illustration of tech tree structures of three different races. Figure 3.10 shows that Protoss tech tree is a branch tree. Terran tech tree is basic divergence linear, as shown in Figure 3.11. Moreover, Zerg tech tree is a disperse tree, as shown in Figure 3.12. Thus the different structures determine that Zerg has a strategy critical point in the opening stage, but Terran and Protoss have no such point.

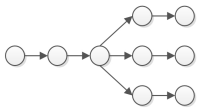

Figure 3.10: Protoss's tech tree structure

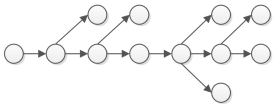

Figure 3.11: Terran's tech tree structure

Compared with the StarCraft II ladder race ratio in Table 3.6, it is found that the race Zerg has been selected with highest percentage in every local server. Behind that, the

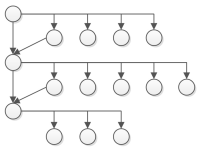

Figure 3.12: Zerg's tech tree structure

Table 3.6: StarCraft II ladder race ratio of grandmaster group

Server	Terran	Zerg	Protoss	Random
US	23.5%	38%	36.5%	2%
EU	23.8%	40.5%	34.7%	1%
China	25.5%	35.8%	34.3%	4.4%
Korea & Taiwan	30.1%	32.5%	32.5%	4.9%

second popular race is Protoss. Consider the operation difficulty, the results mainly fit the research result. In addition, as shown in Figure 3.13 [14], we notice that the wining percentage of Terran is lower than Protoss. Actually, Protoss is much easier to control, while Terran and Protoss's player has the same APM(Actions Per Minute), Terran's player has less chance to win. According to the nature of StarCraft II, many players play the game not only for fun, but also for winning the competition, even though Terran is more interesting than Protoss, they prefer to choose the latter.

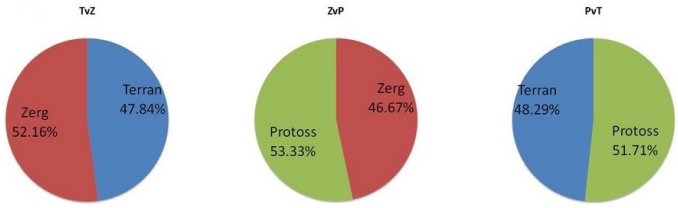

Figure 3.13: wining percentage of three races

3.5 Conclusion

While introducing the concept of strategy tree, the game refinement measure has been calculated for three different races in the opening game of StarCraft II. Thus, it is possible to compare the degree of game refinement or engagement of RTS games with other type of gamers such as board games and sports games. We conclude that the resulting game refinement values of StarCraft II, as measured by game refinement theory, support the previous assumptions of a balanced window of game sophistication around 0.07-0.08.

Chapter 4

Quantifying Engagement of Various Electronic Sports Game

The contents of this chapter has been published in:
1. *Shuo XIONG, Long ZUO, R. Chiewvanichakorn and H. Iida. Quantifying Engagement of Various Games, The 19th Game Programming Workshop (GPW-14), Hakone, pages 101-106.*
2. *Shuo XIONG, Long ZUO, H. Iida (2014). Quantifying Engagement of Electronic Sports Game, Advances in Social and Behavioral Sciences Vols.5-6, pages 37-42.*

4.1 Introduction

Many efforts have been devoted to the study of strategic decision making in the framework of game theory with focus on mathematical models of conflict and cooperation between intelligent rational decision-makers or game-players. Game theory originated in the idea regarding the existence of mixed-strategy equilibria in two-person zero-sum games [7], which has been widely recognized as a useful tool in many fields such as economics, political science, psychology, logic and biology.

However, little is known about mathematical theory from the game creator's point of view. An early work in this direction has been done by Iida *et al.* [6], in which a measure of game refinement was proposed based on the concept of game outcome uncertainty. A logistic model was constructed in the framework of game-refinement theory and applied to many board games including chess variants.

4.2 Game Refinement Theory

4.2.1 Mathematical Model of Game Refinement

Recently a general model of game refinement was proposed based on the concept of game progress and game information progress [11]. It bridges a gap between board games such

as chess and sports games such as soccer and basketball.

Game information progress presents how certain is the result of the game in a certain time or steps. Let G and T be the average number of successful shoots and the average number of shoots per game, respectively. If one knows the game information progress, for example after the game, the game progress $x(t)$ will be given as a linear function of time t with $0 \leq t \leq T$ and $0 \leq x(t) \leq G$, as shown in Equation (4.5).

$$x(t) = \frac{G}{T}\, t \tag{4.1}$$

However, the game information progress given by Equation (4.5) is usually unknown during the in-game period. Hence, the game information progress is reasonably assumed to be exponential. This is because the game outcome is uncertain until the very end of game in many games. Hence, a realistic model of game information progress is given by Equation (4.2).

$$x(t) = G(\frac{t}{T})^n \tag{4.2}$$

Here n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Equation (4.2) twice. Solving it at $t = T$, the equation becomes

$$x''(T) = \frac{Gn(n-1)}{T^n} t^{n-2} = \frac{G}{T^2} n(n-1)$$

It is assumed in the current model that the game information progress in any type of games is happening in our minds. We do not know yet about the physics in our minds, but it is likely that the acceleration of information progress is related to the force in mind. Hence, it is reasonably expected that the larger the value $\frac{G}{T^2}$ is, the more the game becomes exciting due to the uncertainty of game outcome. Thus, we use its root square, $\frac{\sqrt{G}}{T}$, as a game refinement measure for the game considered.

4.2.2 Game Progress Model and Board Games

Here we consider the gap between board games and sports games by deriving a formula to calculate the game information progress of board games. Let B and D be average branching factor (number of possible options) and game length (depth of whole game tree), respectively. One round in board games can be illustrated as decision tree. At each depth of the game tree, one will choose a move and the game will progress. Figure 4.1 illustrates one level of game tree. The distance d, which has been shown in Figure 4.1, can be found by using simple Pythagoras theorem, thus resulting in $d = \sqrt{\Delta l^2 + 1}$.

Assuming that the approximate value of horizontal difference between nodes is $\frac{B}{2}$, then we can make a substitution and get $d = \sqrt{(\frac{B}{2})^2 + 1}$. The game progress for one game is the total level of game tree times d. For the meantime, we do not consider Δt^2 because the value ($\Delta t^2 = 1$) is assumed to be much smaller compared to B. The game length will

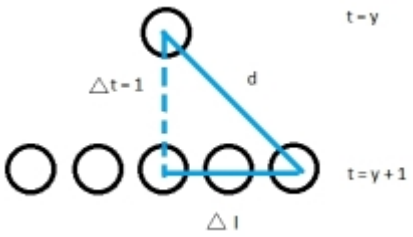

Figure 4.1: Illustration of one level of game tree

be normalized by the average game length D, then the game progress $x(t)$ is given by $x(t) = \frac{t}{D} \cdot d = \frac{t}{D}\sqrt{(\frac{B}{2})^2} = \frac{Bt}{2D}$. Then, in general we have, $x(t) = c\frac{B}{D}t$, where c is a different constant which depends on the game considered. However, we manage to explain how to obtain the game information progress value itself. The game progress in the domain of board games forms a linear graph with the maximum value $x(t)$ of B. Assuming $c = 1$, then we have a realistic game progress model for board games, which is given by

$$x(t) = B(\frac{t}{D})^n. \tag{4.3}$$

Equation (4.3) shows that the game progress in board games corresponds to that of sports games as shown in Equation (4.2).

To support the effectiveness of proposed game refinement measures, some data of games such as Chess and Go [5] from board games and two sports games [11] are compared. We show, in Table 4.1, a comparison of game refinement measures for various type of games. From Table 4.1, we see that sophisticated games have a common factor (i.e., same degree of acceleration value) to feel engagement or excitement regardless of different type of games. Note that average branching factor B and game length D instead of G and T can be used in the board game case [11].

4.3 Further Investigation with Various Games

In this study, we show further investigation in the domains of MOBA games such as DotA, Fighting games such as Super Street Fighter 4 (SSF4) and The King of Fighters 98, 13 (KOF98, KOF13), RTS games such as StarCraft II.

To support the effectiveness of proposed game refinement measures, we show, in Table 4.1,game refinement measures for various games. We see that sophisticated games have a common factor (i.e., same degree of acceleration value) to feel engagement or excitement regardless of different type of games. In the following subsections we show how to apply game refinement theory in different game areas and types. For sports games, we will use the function of $\sqrt{G}T$ (G means average number of successful shoots and T means the average number of shoots per game); while a game which belongs to brain game, then we should use the model of $\sqrt{B}D$ (B stands for average branching factor and D for depth

of the game) for reference. As we know, the physical formula momentum theorem $I = mv$ $=Ft$, the format of I is the same, but the meaning of mv and Ft is quite different.

Table 4.1: Measures of game refinement for board games and sports games

Game	G	T	R
Chess	35	80	0.074
Go	250	208	0.076
Basketball	36.38	82.01	0.073
Soccer	2.64	22	0.073
Badminton	46.336	79.344	0.086
Table tennis	54.863	96.465	0.077
DotA ver 6.80	68.6	106.2	0.078
UFO catcher	0.967	13.30	0.074
StarCraft II Terran	1.64	16	0.0805

4.3.1 Fighting Game: Super Street Fighter and The King of Fighters

Fighting game is a video game genre in which a player controls an on-screen character and engages in close combat with an opponent. These characters tend to be of equal power and fight matches consisting of several rounds, which take place in an arena [8]. Similar as the football or basketball, for the fighting game, players control the character to attack each other, some attack is valid (hit opponent without defense, then make damage successfully). On the other hand, every attack is an attempt no matter it is successful or not, so in this condition, G stands for the average number of successful damage and T for average number of attack per game. Then three famous games are selected to collect the data and do the corresponding analysis. Generally, according to the players' experience and feeling, Super Street Fighter 4 has the slower game rhythm and nice balance between every characters, while players attend a match, they need to focus on the psychological anticipation; The King of Fighters series has the higher game rhythm and excellent ornamental value, players need to focus on the combo. Therefore, refinement values of these two games should be different. According to the data and Table 4.2 shows, game refinement value of Super Street Fighter 4 is close to the traditional board games and sports games such as soccer, and The King of the Fighters has the exorbitant R-value which means that the game is interesting and exciting or we can say thisgame is good for watching but not so suitable for sports competition. The research result and experiment data fit the players' experience and audiences' feeling.

4.3.2 Score Limited Games

The sports game can be divided into two types, score limit game such as tennis and badminton, time limit game such as basketball and soccer.In a score-based game, the

Table 4.2: Measures of game refinement for Fighting games

version	G	T	R-value
Super Street Fighters 4	19.4	61.5	0.0716
The King of the Fighters 98	14.6	36.7	0.1041
The King of the Fighters 13	26.5	44.8	0.1149

measure of refinement was proposed based on the information gained from the game and the average game length. So we choose the formula for body game and redefine the G and T. Because the score limit game full length depend on the winner player achieve the goal points and plus the points which the loser got, so the T stands for the total score of the entire game. In time limit game such as soccer, representation of successful shoots is POINT or SCORE, as same as time limit game, G stands for the total score successfully made by the winning side. According to the meaning of Equation 1, we can take the example of badminton. In recent years, the rules of badminton had been changed by serval times, depend on the rules, competition data can be corrected and calculate the game refinement value of badminton as Table 4.3 shows.[8]

Table 4.3: Measure of game refinement for Badminton

Scoring system	Winning score (G)	Total score (T)	R
Old	30.070	45.145	0.121
Current	46.336	79.344	0.086

4.3.3 MOBA Game: DotA

[35]Multi-player Online Battle Arena(MOBA) game , in which a player controls a single character at one of two teams. The objective is to destroy the opposing team's main structure with the assistance of periodically spawned computer-controlled units that march forward along set paths. Player characters typically have various abilities and advantages that improve over the course of a game and that contribute to a team's overall strategy. Usually, the behind side will input GG (good game) when they find that there is no hope to win, which means that they give up and quit the game.

We consider DotA's game progress. Although DotA or LOL belong to e-sports game, essentially access the body game, so we also can simulate the $\frac{\sqrt{G}}{T}$. It can be measured by two factors: to kill heroes and to destroy towers. Let K and A be the average number of successful killing heroes and destroying towers, and the average number of attempts per game, respectively. If one knows the game information progress, for example after the game, the game progress x(t) will be given by Equation 4.[35]

$$x(t) = \frac{K}{A}\, t \tag{4.4}$$

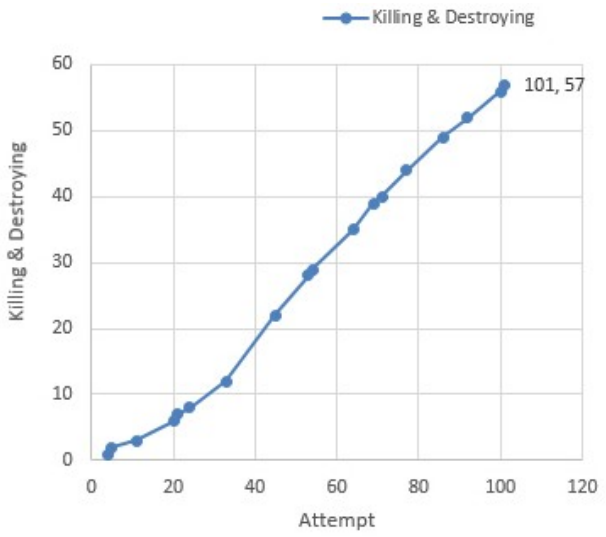

Figure 4.2: Game progress of a replay on DotA ver. 6.74

Table 4.4: Measures of game refinement for historical versions of DotA

version	released	K & D	A	R-value
6.48	Aug 2007	69.2	110.8	0.075
6.51	Mar 2008	68.4	110.2	0.074
6.59	Jan 2009	69.8	110.0	0.076
6.61	Aug 2009	70.0	111.6	0.075
6.64	Oct 2009	68.4	110.4	0.075
6.69	Oct 2010	67.8	108.4	0.076
6.74	Mar 2012	62.4	102.6	0.077
6.77	Dec 2012	62.8	102.8	0.077
6.80	Mar 2014	68.6	106.2	0.078

Similarly, we have the game refinement formula

$$R = \frac{\sqrt{K}}{A} \tag{4.5}$$

According some auxiliary software, we can correct the data of DotA as Figure 4.2 shows

We download five replays of each version on website. The players in the game are all expert players in order to make the data more objective and reasonable. A software called replay manager is used for this study to collect the data of killing and the destroyed towers of each game. The attempt is counted by watching replays. We show, in Table 4.4, the results of different DotA versions using game refinement measure by computer system. We played the related versions with other players on platform and collected five replays of each related version.

4.3.4 RTS Game: StarCraft II

[34]StarCraft II, which is one of the most popular RTS games. In typical RTS games, players build armies and vie for control of the battlefield. The armies in play can be as small as a single squad of Marines or as large as a full-blown planetary invasion force. As commander, one observes the battlefield from a top-down perspective and issue orders to one's own units in real time. Strategic thinking is key to success. Players need to gather information about the opponents, anticipate their moves, outflank their attacks, and formulate a winning strategy. StarCraft II features three distinct races whose armies comprise entirely unique units and structures. Each race has its own strengths and weaknesses, and knowing their tactical profiles can mean the difference between glorious victory or crushing defeat.

Our present study focuses on StarCraft II which is a RTS game where the player's goal is to destroy their enemy's base by developing their own base and an army. In StarCraft II players cannot see their opponent's situation and they have the same power, StarCraft II does not rely on any chance. Therefore, in a sense this game is similar with board games such as chess. It means that we can use some similar tools $\frac{\sqrt{B}}{D}$ to analyze the game of StarCraft II.

According to the game features of StarCraft II, we should divide the game into four part: Opening, Mid-prophase, Mid-anaphase and Endgame. The game could finish in any time domain. For example, while players choose supervise attack or extremely rush strategy, the game must finish in 7 or 8 minutes or before; Normally, the average game time is 15 to 20 minutes (it means the most games will not enter into Mid-anaphase or Endgame time domain).[34] As our experience, we find the game in different time domain, the **main elements** are completely disparate!

Table 4.5: Feature of Starcraft II in every process

Domain	Timing	Character
Opening	0 to 10 minutes	Strategy
Mid-prophase	10 to 20 minutes	Economy and Management
Mid-anaphase	20 to 30 minutes	Economy and Operation
Endgame	Over 30 minutes	operation

In the opening, the StarCraft II is similar to real war or traditional board games. In other words, only in opening time domain, StarCraft II is an intellectual game. While a game enters into Mid-prophase or Mid-anaphase, the main elements are economy, management and operation, it means that in mid-game, the StarCraft II is similar to the Simulation Game! As we know, a good chess player not always can be a good manager, a strategy genius does not mean that he could be a nice executive.

For the endgame, the operation element will be more and more important, even occupy all the StarCraft II process. It means that on that time StarCraft II is similar to Super Mario. When we watch somebody playing Super Mario, we rarely focus on his intellectual strategy, we only focus on whether or not his operation skill is proficient. In this situation, StarCraft II is like sports games such as soccer and basketball.

Figure 4.3: Feature of StarCraft II

According to the above, only in the opening stage, we have the strategy tree, and then find the B and D. Also in the opening stage, the game is highly similar to traditional board games or brain sports, we can take example by game tree model to establish new mathematical model. If we want to research mid-game or end game, we must find other model or method. At least, the meaning of B and D must be changed. Actually, the completion between profession players, the most exciting and wonderful part is mid-game.

Since StarCraft II is a RTS game, its minimax tree[9] cannot be built in a normal way. For example, the depth of tree is defined by each step or turn, while in Starcraft II, the depth might be given by time evolution. We show, in Figure 4.4, such an example. In Figure 4.4, we notice that the child node "Tokyo" and child node "Shanghai" have the different depth. This situation would never happen in traditional board games to build a minimax search tree. So we consider one method to solve it, while changing an unbalance depth tree into a balance tree. While add the temporary node, then we get another strategy tree of as shown in Figure 4.5.

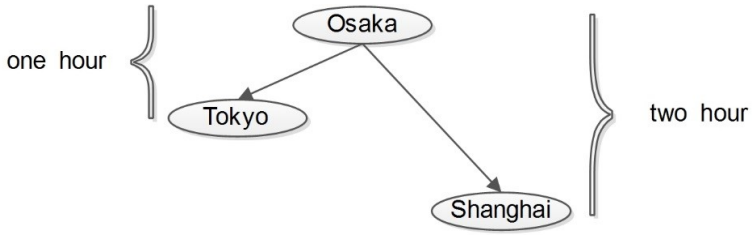

Figure 4.4: An example of strategy tree with two unbalanced child nodes

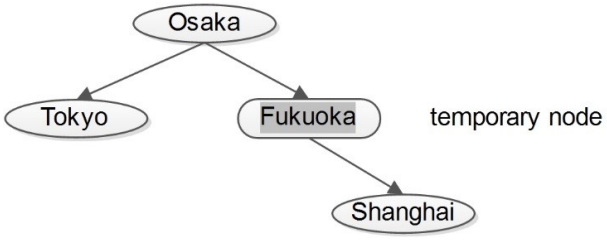

Figure 4.5: The strategy tree with temporary node

Then the game refinement value is calculated, as shown in Table 4.6.

Table 4.6: Measure of game refinement for three races in Starcraft II

Race	all nodes	all parent nodes	B	D	R-value
Terran	126	76	1.64	16	0.0805
Zerg	219	141	1.54	18	0.0692
Zerg*	564	210	1.61	20	0.0819
Protoss	116	74	1.55	18	0.0691

Table 4.7: Measures of game refinement for crane game

country	P	T	R-value
Japan	0.967	13.13	0.075
Thailand	0.367	10.65	0.057

4.3.5 Crane game: UFO Catcher

Final one is the crane game, which is a type of arcade games, it is very popular among most people around the world, especially teenagers.

From the game characteristic which is coin-operated, the playing cost is one of the factors which affects player's enjoyment in game. We propose c as a cost per each attempt normalized by the average cost per attempt of each country, since the playing costs are varied for different machines. Let P and T be average number of prizes captured, and average number of attempts, respectively[34]. Similarly as the Section 1 wrote, we have the function:

$$x(t) = \frac{P}{cT}\ t \tag{4.6}$$

A model of game information progress for crane game is given by Equation (4.7).

$$x(t) = P(\frac{t}{cT})^n \tag{4.7}$$

Here n stands for a constant parameter which is given based on the perspective of an observer in the game considered. Then acceleration of game information progress is obtained by deriving Equation (4.7) twice. Solving it at $t = cT$, the equation becomes

$$x''(cT) = \frac{Pn(n-1)}{c^n T^n} t^{n-2} = \frac{P}{c^2 T^2} n(n-1)$$

then expect $\frac{P}{c^2T^2}$ or its root square $\frac{\sqrt{P}}{cT}$ to be a game refinement measure for crane games. Consequently, we suppose that the larger the game refinement value is, the more attractive the game becomes. An experiment has been preliminarily carried out by observing crane game players in amusement centers in different countries. We collected data of 30 and 60 game samples from Japan and Thailand respectively. Then game refinement theory was applied. The results of the experiments are compared in Table 4.7.

4.4 Conclusion

In this Chapter, we proved the formula $R = \frac{\sqrt{B}}{D} = \frac{\sqrt{G}}{T}$. Accodring to the game process, we can divide game into brain game (Focus on Strategy) and body game (Focus on skill), then choose the corresponding model to analyze them. Game refinement theory can succussfully be used in every type of game, it can be a good tool to help game designer to make rules or set the game model. As a tentative conclusion, we observe that any kind of attractive games would have the similar zone value (say $0.07 - 0.08$) of game refinement.

Chapter 5

The Problems With Modern Japanese and Chinese Game Seclusion From the Outside World and In-Depth Analysis of the Countermeasures

The contents of this chapter has been published in:
1. *Shuo XIONG (2014). The Problems With Modern Japanese and Chinese Game Seclusion From the Outside World and In-depth Analysis of the Countermeasures, Journal of US-China Public Administration, 11(4): 334-344.*

5.1 Introduction

Games are a part of our lives. Games came into the world together with the advent of tools. Over 5,500 years ago, Senet was played in Pre-dynastic Egypt, as evidenced by its inclusion in burial sites[16]. Until now, the four most popular classic board games have been Go, Chess, Xiangqi, and Shogi [17]. Excepting Go, these games share some remarkable similarities, even down the shape and movement of the pieces. In Chess, Xiangqi, and Shogi, for example, the knights (horse) all move in an L shaped fashion. According to some researches, the Indian game Chaturanga is identified as the ancestor of Xiangqi, Shogi, and Chess[18].

The game of Go or Weiqi in Chinese enjoys a special place in board game history. Not only it is one of the oldest games known, it has kept essentially the same rules for longer than any other board game. After its origins in China perhaps as far back as 2300 B.C.[30], Go spread into Korea in the 2nd century, and finally traveled to Japan via trade routes sometime around the year 700 A.D. [30].

The idea of the board game can be defined in a more generalized concept, not only

board games but also including card games like Mahjong. Mahjong originates from the Tang Dynasty in China [16]. Whether its original form was paper and it later moved onto tiles, or whether it began as tiles and cards later developed from it, most of the length of its early history has been recorded as being limited to the aristocracy. The rules were kept secret until China became a republic early in the last century. It is very likely that the earliest versions of the game would bear little resemblance to the game as played today [30].

Only in 1920 did Mahjong step outside the country and spread, first to the United States, then Japan, and around the world [16]. An interesting development was recently shown in the news reports of an international Mahjong competition where French players took home the top prizes, with the Chinese teams only managing to come the fourth and seventh [37].

Cleverly, marketed board games can gain worldwide popularity. Chinese designers developed a game called Three-Kingdoms Kill, this game's principle is based on Bang[19].

5.2 The Meaning of "Sakoku" and Sakoku Model in Modern Asian Game

In the 19th century, both China and Japan had policies of seclusion from the outside world. On the surface, they were similar government policies. Both of them restricted international travel, both countries prohibited Catholicism, and both strictly regulated international trade. However, the deep-seated reasons have many different points. Limited to its only window to the outside world, the designated international port of Nagasaki, Japanese leadership could remain somewhat informed of the day's global technology. The Chinese of the day considered Chinese culture as superior, and refused all knowledge of the West, thereby missing hundreds of years of science, medicine, and philosophical advancement. The arrogance of Chinese national character in that age retarded China's growth, while Japan's fears retarded hers. According to this history, sakoku can be viewed on its relation with two elements: government policy and national character.

Compared with the success of the traditional and fashion board game, the new media games seem unfortunate. Chinese and American games are hardly keeping a foothold in the Japan market[37]. Few Japanese players know the Starcraft II or Diablo III which are famous and popular all over the world. On the other hand, except some light games which face to light user, many Japanese games are hardly to make the success in Western and China market, such as Monster Hunter [28][29].

The writer calls this phenomenon with a Japanese word Game Sakoku. There are four points at the root of this problem: government policies, economy, national mind, and poor marketing. Some genius Japanese game designers such as Kojima Hideo [22] and Keji Inafune also have already said as much [37].

First, to illuminate the concept of Game sakoku in detail, a brief discussion and the results of research were began. A note on the word sakokuthere is some difference in meaning between Chinese and Japanese with this word. Japanese seems to have a more

emotionally charged connotation to the word phrase meaning "seclusion from the outside world" when it is written in Chinese characters. In Japanese, sakoku is strongly related with government behavior, such as the historic Tokugawa Bakufu. However, this word in Chinese (suoguo) is more generalized, connoting not only government behavior, but extending to the economy, company behavior, and national character or mind [**?**]. The Chinese game industry is in the development period and the Japanese game hardware industry is in its heyday. If the sakoku problem is not solved, the Japanese game industry will decline and fall behind that of the West. For their part, Chinese developers who fail to address gamers beyond their borders stand to lose the best chance to step into the development of the gaming future [33].

5.3 Methodology

Field investigations were begun when the writer resided among the crowded arcade lines streets of Osaka, Japan. The similar e-novels games are sold at premium prices within Japan, even higher than masterpieces such as "Assassin's Creed" or "Call of Duty". If it is any indication of their popularity, Japanese game shops are full of these new assembly line production games. Japanese gamers' customs and interests can also be observed, which shall be compared with Chinese and other customs [29].

A questionnaire of the gaming public in three languages was undertaken in order to highlight some of the opinions, habits, or feelings of the gaming public. The questionnaire has 59 questions in the Japanese version (answer n = 22), 60 questions in the Chinese version (n = 615), and 58 questions in the English version (n = 17). According to the research data, the Japanese game sakoku problem will be shown with four points: the irrational game price and excessive commercialization, opposite phenomenon, weak innovative ability in recent years, and weak adaptability in overseas market.

The following four points will then be made concerning the Chinese game market: public policy, law and review mechanism, rampant piracy version, and players' economic capability and customs. These points are closely connected to the Japanese four points. They are the main reasons for low sales of Japanese games in the Chinese market [28][29].

5.4 Japan Part

5.4.1 The Excessive Commercialization and Game Price

The price of the Japanese game is higher than the other countries. For example, the average price of an "Adventure Game (AVG)" is 6,500 yen, even with games which are simply electronic novels. The game programming required for such a production is very easy, and any student who has begun to study the C language can also write the source code of electronic novel AVGs. On the other hand, with a masterpiece of the West such as "Call of Duty 9", the resources are millions of times harder than the electronic novel games. However, the price of this game is $59 US dollars, which is cheaper than the electronic novel AVG.

Compare the graphics, the AVG games may only need some 2D pictures to be the background, but "Call of Duty 9" or "Assassin's Creed III" contains very complicated 3D effects and modeling. Comparing with the game play, an AVG like Ace Attorney is the most famous AVG, which is often played only once, and never touched again, once the plot is known. Games such as Warcraft or Starcraft, however, are different each time, and can be enjoyed repeatedly, just like GO.

Not only the high price, but also the excessive commercialization make much worse with that. Because of excessive commercialization, many games are made by assembly lines.

More serious is when company and game design get value from assembly lines, they will rely on that.

5.4.2 Opposite Phenomenon

Considering the "Opposite Phenomenon", games such as Warcraft III, Starcraft II [2], Diablo III, Dota (Defense of the Ancients) [15], LOL (League of Legends) [32], and Counter-Strike are very famous games anywhere in the world; people play them in America, Europe, China, Korea, and other Asia counties, but in Japan, these games are hardly played. On the contrary, few Japanese know them at all.

Every year, there are many electronic competitions such as "WCG" (World Cyber Games) held all over the worldattendance will reveal almost no Japanese player joining in these competitions. There are two questionnaire data to show that(see Figure 5.1, Figure 5.2, Figure 5.3 and Figure 5.4). Sample name recongnition of three games by Japanese, Chinese, and Western players follows for "DotA, LOL, and StarCraft".

The opposite phenomenon affects the competitiveness of Japanese gamers, and likewise some famous Japanese game makers cannot get out of the country. In terms of the following anecdotal evidences, we take Monster Hunter as one example. In Japan, Monster Hunter is a nationally recognized Japanese game. People can often be seen playing Monster Hunter on PSP in the bus, in the subway station, and most public places. Certainly, Monster Hunter is an interesting and playable game that appeals to many people. Probably Monster Hunter could be received well among society members, just like the "WOW (World of Warcraft)" in other countries. However, while Japanese players are crazy about this game, Western player do not even know what Monster Hunter is.

Monster Hunter is a game that could be translated and marketed effectively to the West. At least the game is easier to understand than "Nobunaga's Ambition". Moreover, even Dynasty Warriors and "Samurai Warriors" have an English version [24]. In respect to games like Warcraft III and Monster Hunter, this puzzling situation is the opposite phenomenona sense that Japanese and other countries' players are living in different worlds.

Obviously, the causes of the opposite phenomenon could be culturally, historically, and idiosyncratically complex among all the various players, developers, and marketers of games. Surely one reason is national personality. As it can be seen, this result came from the "Digital Game Textbook" [20].

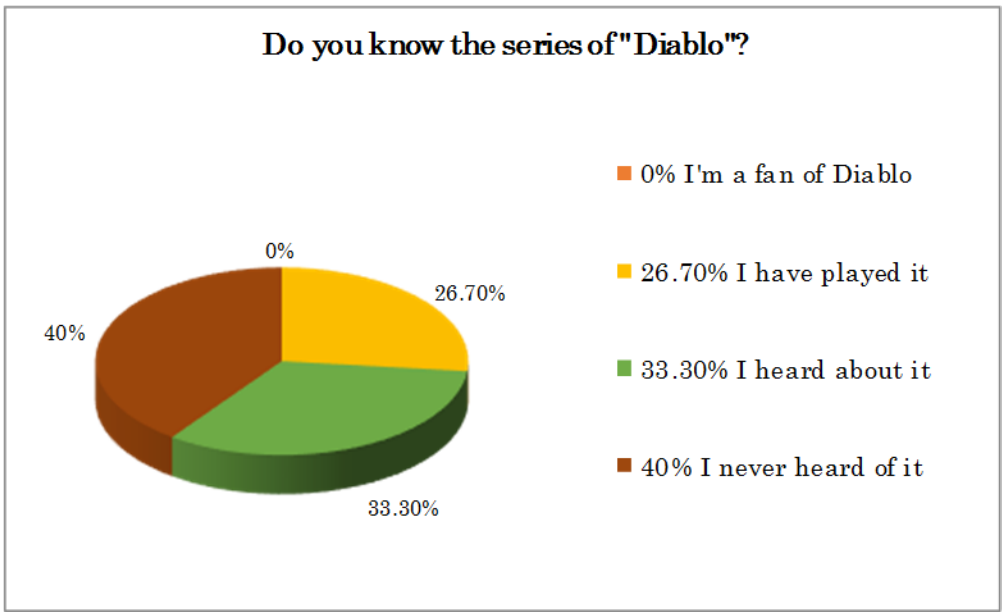

Figure 5.1: Recognition of Diablo in Japan

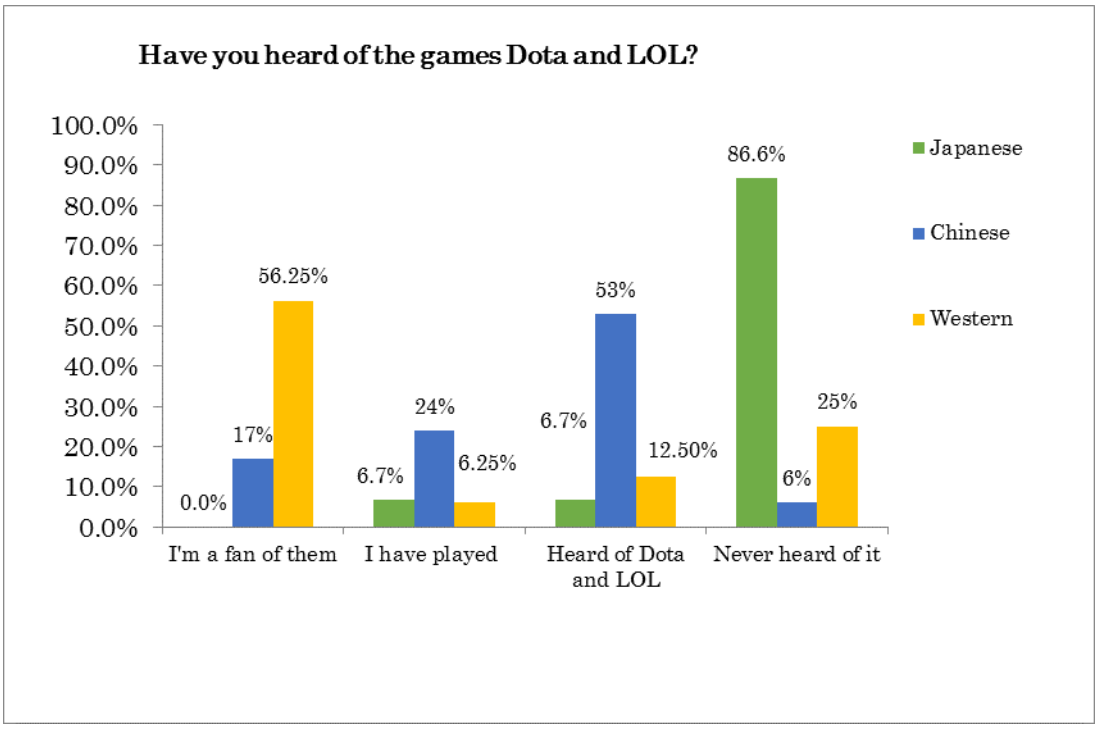

Figure 5.2: Recognition of Dota&LOL

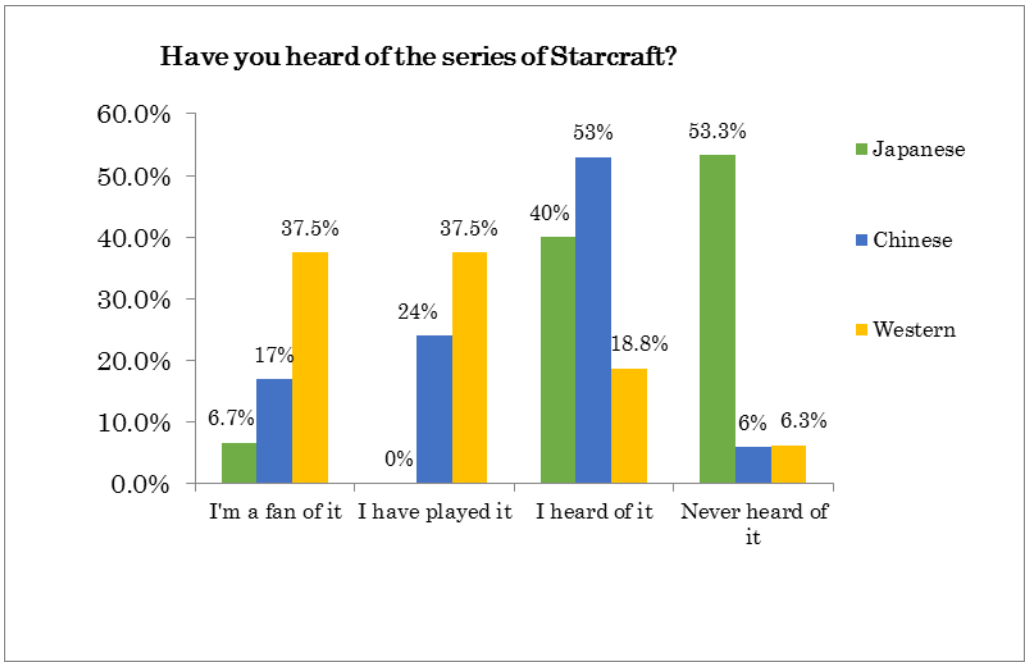

Figure 5.3: Recognition of Starcraft

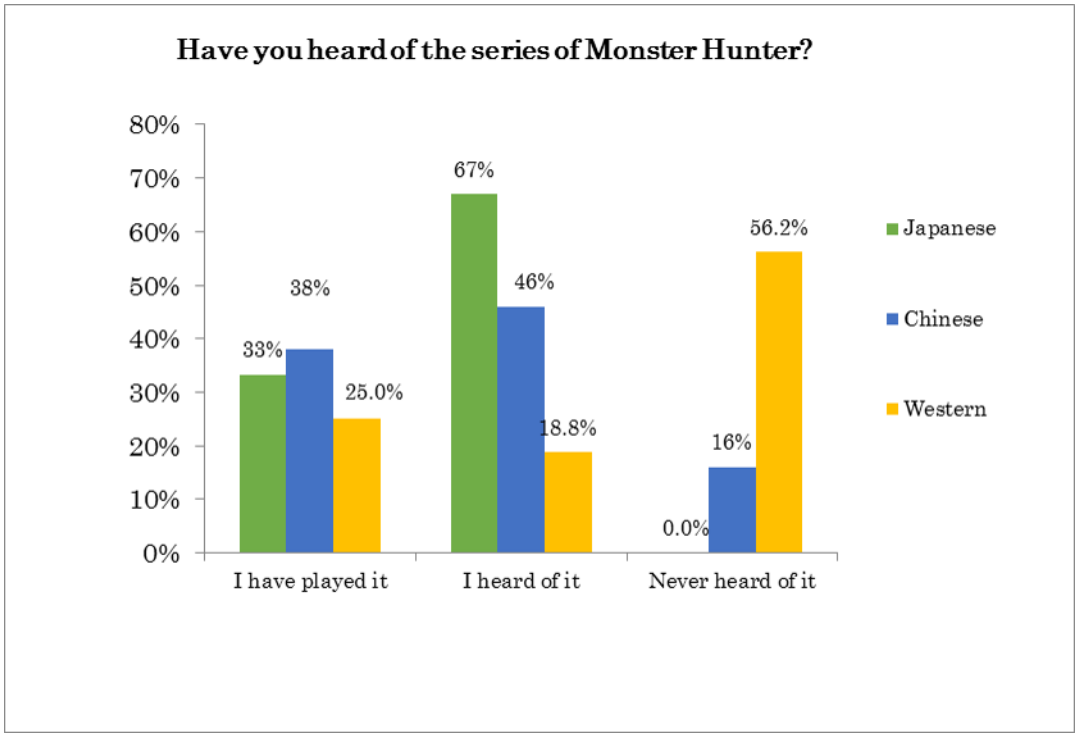

Figure 5.4: Recognition of Monster Hunter

Table 5.1: The number of overseas game in Japan Top 100 Title List

Year	Make by overseas title
2005	1
2006	0
2007	2
2008	1
2009	0

In Table 5.1, the result of the number of overseas game in Japan top 100-titlelist is shocking.

5.4.3 Innovative Ability Is Weak in Recent Years

Some Japanese games are the same as those which are famous anywhere else in the world, such as Biohazard 6, Final Fantasy 13, and Devil May Cry 5. However, the other games have a later suffix name, and their origins are all before the PS3 and XBOX 360 age. In other words, 88.6% of the games on this list are Japanese games that are based on their famous first installments. Biohazard first appeared in 1998, and Final Fantasy was made in 1987. The fact that these games are dependent upon 15 to 25 years old ideas is a strong indication of flagging innovation in Japanese game production.

Comparing the Western titles with such games as Need for Speed 17, Tomb Raider 8, and The Elder Scrolls V: Skyrim, based on their classic tags, still there are also a lot of new series created after 2006 such as Assassin's Creed, Mass Effect, and Alan Wake.

Perhaps the best instance of "Call of Duty" best explains the self-revolution ability of Western companies. The series of "Call of Duty" was initially based on the theme about the Second World War [actually the "Call of Duty" is really one of the excellent FPS (First-Personal Shooting) games at that time, and along with such competitors as "Medal of Honor" and "Battlefield 1942"]. In 2007, FPS players around the Game-o-Sphere were jolted by the Activision self-revolution: Call of Duty 4. This version changed the theme from a Second World War game to a modern age game. With a Hollywood movie effect, Call of Duty 4: Modern warfare truly took the gaming world by surprise. Subsequently, Modern Warfare 2 and Modern Warfare 3 sold out in 2009 and 2011. Apparently, the massive changes were a success, Call of Duty: Modern Warfare 3 had earned 775 million dollars just in five days[7]. Game companies ought to have the self-revolution spirit, not only with heritage classics, but also to reclaim new areas.

5.4.4 Weak Adaptability in Overseas Market

Whether they even make an attempt to do so, it seems that the products of Japanese game company do not appear widely out of the Japanese market, especially in China. In fact, one would be very hard pressed to find a copyrighted Japanese game in China. Of course, some of the blame for this falls on the Chinese Government and players themselves, as will be discussed in the next section. If Japanese game companies would like to penetrate into

Chinese market space, however, they will first need to face the piracy problem and the absence of a review mechanism. While these are indeed serious issues, piracy and review mechanics do not seem sufficient deterrents in and of themselves to cause failure. Western companies such as Blizzard have been successful in China because they could adapt to the environment, and many South Korean companies could also keep their foothold. As long as they are willing to address these concerns, Japanese companies can thrive in the Chinese game market, too.

5.5 China Part

5.5.1 Policy, Law, and Review Mechanism

Most countries have a ratings system for mass media. Unfortunately, China has no standard ratings system [23]. That means that every player, regardless of age, should play under the same draconian restrictions. The reason for this and many other deficiencies of Chinese culture politic are complicated. The effect is apparent: Any game which contains bloody, erotic, violent, profane or sensitive political or historical content is basically forbidden. Modern game designs that are in high demand can hardly avoid at least some of these elements. In the Mainland China server version of Starcraft II, all the effects of death are censored, and the red blood becomes black like petroleum. Game companies should produce Chinese market versions of their games.

This review mechanism in the absence of any standardized ratings system serves the mainland Chinese game and movie industry and Chinese consumers very poorly. Furthermore, as a student determined to become a game designer, the writer would like to create a game about the Republic of China age someday. This age provides the richest part of Chinas history, and many exciting elements provide potential subject matter for game designs: frequent wars and cataclysmic world events, thousands of civil servants, generals and heroes, and the crossroads of many different forces.

It is a pity that the game would like not make it out of the review process in China because the Republic of China Age is a too sensitive historical topic. This simple reason kills many excellent game ideas and plans. Additionally, this is the main reason why foreign games cannot access the Chinese market.

Other laws also hinder the Chinese game industry. For example, game machines themselves are unlawful in China for a long time (until 2013). Game machines cannot come into Chinese market by any legal means. This results in not only the great masses of players who are deprived of PS3s or PSVs, but also Chinese game companies are unable to make games on these platforms because they do not know the kernel information about these machines. Ironically, though, game machines can be found for purchase anywhere in China through unconventional means. In addition, game information and strategies are discussed openly on the internet, and video game magazines are sold in every bookshop. It belongs to the gray area. However, this situation has been changed, China Government just modifies the policy in 2014. Accompanying Shanghai FTA (Free Trade Agreement) being established, the game machine can now be sold legally. It is a big and good chance

for all the game hardware company.

5.5.2 Rampant Piracy Version and Players' Economic Capability and Customs

Piracy is a global problem, but it is more serious in China. The following circular graph explains the detrimental cycle. Figure 5.5 is the model about forever endless vicious circle of piracy version.

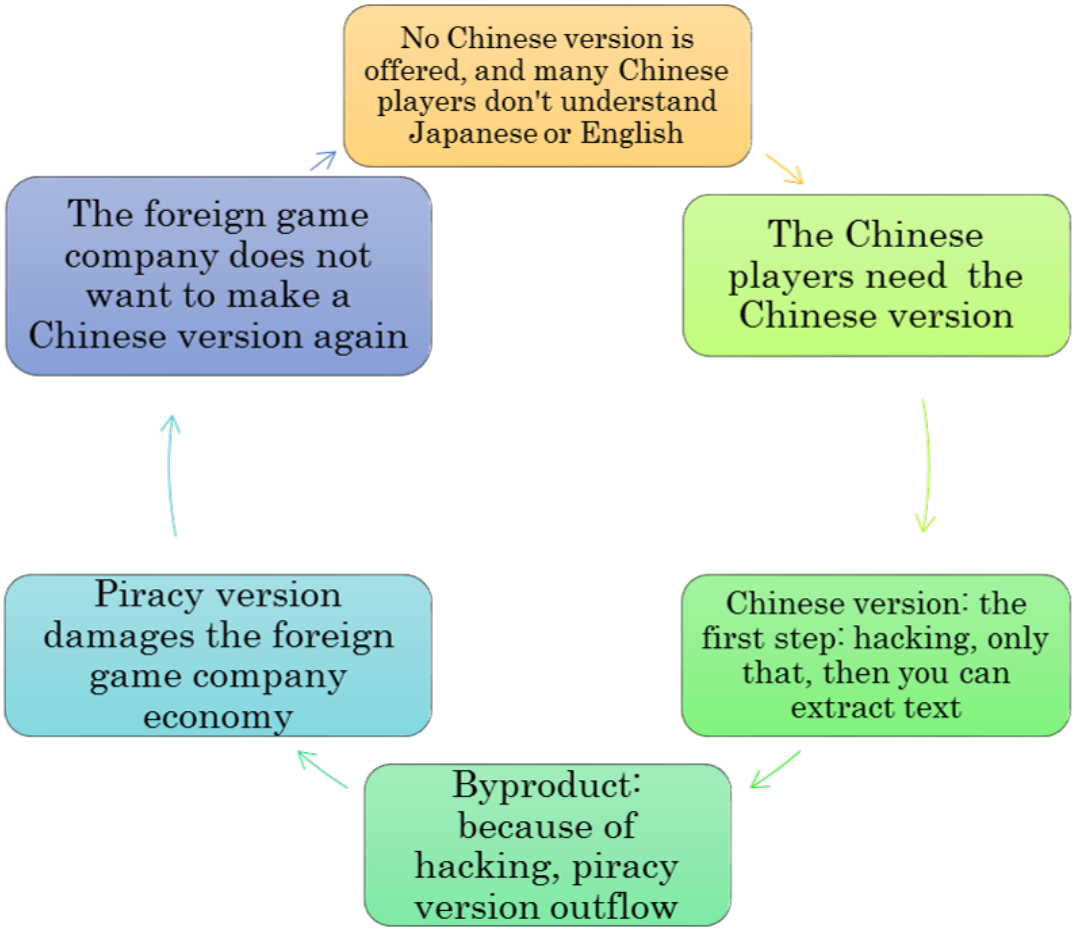

Figure 5.5: Forever-endless Vicious Circle

That is the present situation. Rampant piracy is the biggest problem which is hindering the Chinese game industry and isolates the Chinese game industry from the outside world. Piracy damages the game industry all over the world. For the Chinese market, native companies and Japanese companies are deeply damaged. Online games are the most important part of the game industry in China, but the video game is nearing a state of collapse [21]. This is easily explained by the fable of the "Warm Boiled Frog". The frog will feel pain if thrown into hot water, but if thrown into cold water, then gently raising

the temperature, the frog will face death quietly and joyfully. This anecdote makes a quirky image perhaps, but there is a very real implication for anyone wishing to sell a product in China. Japanese companies lose a lot of their potential market share to this phenomenon, because Chinese gamers even if they may ultimately spend the same amount or more, will choose the cheaper per-pay game almost every time. Considering that the average Chinese per capita income is only one-tenth of that of Japanese [26]. Chinese players are more reluctant to part with their scant money for a game which cannot be eaten, keep a person warm, or contribute to the running of a business.

Blizzard used the "Warm Boiled Frog" method, such as with the marketing of WOW and earned decent profits in China market [21]. Some other South Korean and Chinese game companies have had success with this model. The game is free but equipment must be bought at a premium. Global gaming marketers absolutely must accurately address Chinese players' vanity and psychological treatment to succeed in China.

As is well known, China is a developing country whose citizens have considerably less economic wherewithal than those of more economically developed countries. Secondly, though, the law and review mechanism ban many games; Chinese players wishing to experience them must choose between pirated and smuggled game versions. These are the two main causes of rampant game piracy in China.

5.6 Countermeasures and Summary

This research arrives at an uncomfortable question: How is it that traditional board games can cross the geographical and cultural chasm in the pre-industrial age, but digital games cannot do so even in the information age? With the development of internet, players should acquire the game information easily. It is a serious and sad condition. In order to improve these conditions, several solutions are now proposed that, if implemented, will grow the sustainable development capacity of the modern game industry. East-Asia cultural stock is well positioned to provide good influence all over the world. Japanese companies can earn handsome profits in China, and improved communication and understanding among Japan, China, and the world can be achieved with better business and enjoyment of games.

Summing up this analysis is a presentation of countermeasures for ending Japanese and Chinese game industry sakoku. Perhaps the best way for Japanese game companies is to secure agent representation in China, or cooperate with an existing Chinese firm. Actually, many Western game companies (Blizzard, Riot games, and Smile Gate) [37] and Japanese manufacturing firms (Honda, Nissan, and Toyota) are known to have had a big success in the Chinese market.

While this method also comes with its own problems, it has many advantages. As would be expected, the Chinese Government is much more amenable to permitting Chinese companies in the review process. In addition, the Chinese Government protects domestic copyrights. The power of the Chinese Government in China is a strong deterrent to hackers. In practice, China holds itself to a separate standard for independent overseas capital or company.

Other main countermeasures contain these four points: First, the presence of overseas branches is helpful to creating a more local image preferable to Chinese Government and consumers. Especially, considering the price of production, just as for iPhone or so many other products, "Made in China" reduces development cost significantly. Second, modify pricing for the Chinese market, following the logic of the "Warm Boiled Frog". Third, modify game authentication mode. A game company could use the network authentication just like the Diablo III and SimCity 5. Fourth, producers must strongly consider where to strike their balance between projected sales and per-unit profits. Starcraft II in America has an MSRP (Manufacturers Suggested Retail Price) of $59.90, but in China mainland only sells for $14.60. Japanese game company also could follow that example for the opportunity to sell games to millions of Chinese.

Finally, gamers themselves have some measure of power over the world gaming culture. The game associations should encourage Japanese players to participate in the world, for example, by joining in the E-sports such as WCG. Additionally, personnel exchanges among various corporate, NGO (Non-Governmental Organization), and educational entities have helped bridge many cultural gaps and could do much for global gaming culture. Game developers, the media, players, and businesspersons should encourage game designers to open up and innovate. In the future, Japanese game companies could enjoy wonderful success in the Chinese and world market. The Asian modern game contains elements of a vast and ancient past, and values which are strongly desired and respected in the West. This writer believes that Asian digital games can become as popular as the classic board games have been. Moreover, if world players and developers can make communication more freely, the effects of modern day de facto sakoku can be dispelled. Future research of both Japanese and Chinese gaming markets will be undertaken with this noble purpose.

5.7 Conclusions

In this paper, Japan and China game market problems have been shown. According to the contents, Japanese game designers could understand their weak points and imperfections, for the Japanese game companies, they will notice the method to enter into overseas market especial enter into China market then stand firm, obtain perhaps profits. For China side, government and relevant practitioners may introspect the policy, realize the sakoku problems (policy, law, review mechanism, and rampant piracy version), limit and hinder China game industry and economic development, establish the regular view system in the future, and strengthen the protection of copyright. Actually, it is glad to see China Government is changing, in September, 2014, Xbox one will be sold in China by regular pathway.

However, there are some limitations and deficiencies existed in this paper. First, the rootedness of Japanese national character seems so difficult to alter, on the other hand, China Government is powerful and rigid, and it will cost a long period to establish the classifying system. Second, in the section "Opposite phenomenon", the questionnaire data of Japanese and Western are not enough. Third, this paper just shows some surface

phenomenon and lack of deep analysis about why Japanese do not accept other country's game. Fourth, only formulating a reasonable price may not effectively improve the rampant piracy version, game industry personnel need more economy knowledge to make countermeasure.

In the future, researchers should expand the investigation sample to refine the survey result, then dig the deep reasons about Japan sakoku phenomenon to develop effective strategies to solve them. Finally, they should continue this research to find the culture common points and analyze how to sell games successfully in the global market.

Chapter 6

Conclusion and Future Works

In my last years in JAIST, I have studied the game refinement theory which was created by Professor Iida Hiroyuki. Game refinement theory simulate the physical theorem to show the acceleration of game outcome, which was commonly used in traditional board game. However, the theory hardly make a breakthrough for another domain. After the internship student, Mr.Arie, who successfully establish a channel to prove the relationship between board game and sports game, then we can do much more application in various games.

Around the StarCtaft II, I analyze the game refinement theory applied in Non-random incomplete information game, the mathematical model also can be used in various of Real time strategy game. First, I create the concept about strategy tree, then by the tools of temporary node method, we can change the unbalance strategy tree to normal min-max tree. Base on that and over hundred of replay video, we establish a systemic research platform. It is possible to compare the degree of game refinement or engagement of RTS games with other type of gamers such as board games and sports games. We notice that the resulting game refinement values of StarCraft II, as measured by game refinement theory, support the previous assumptions of a balanced window of game sophistication around 0.07-0.08

We also make more applications in other area such as Score Limited game, MOBA game, Fighting game and Arcade Catcher. The student whose name are Mr.Beam, Mr.Zuo, Miss.Prai give me a lot of genius and research idea to complete the paper. With the help of their data, I can do more research object. In fact, we have presented some applications to various types of electronic games. It shows that game refinement theory can successfully be used in every type of games with its appropriate model of game information progress. It can be a useful tool to enable game designers to elaborate a target game to be more sophisticated. As a tentative conclusion, we observed that any kind of attractive games would have the similar zone value of game refinement. That is a very important result for us, no matter the traditional board game(Brain sports) Chess, Go, Xiangqi or Shogi, or the traditional body sports such as Soccer or Badminton, and the new game or electronic sports like StarCraft II or DotA, Super Street Fighters 4 and Crane Game, their refinement values are quite similar. By this idea, while we design any new video/board game or make/change the rule for current game, we can use the tool–

game refinement theory to control our object's value between 0.07–0.08.

Also I want to introduce the concept of electronic sport to Japanese, the current e-sports is very cold in Japan, so focus on the Japan and China game market I write the Chapter 5 then provide the corresponding countermeasure. For the Japanese game companies, they will notice the method to enter into overseas market especial enter into China market then stand firm, obtain perhaps profits. For China side, government and relevant practitioners may introspect the policy, realize the sakoku problems (policy, law, review mechanism, and rampant piracy version), limit and hinder China game industry and economic development, establish the regular view system in the future, and strengthen the protection of copyright. Second, in the section "Opposite phenomenon", the questionnaire data of Japanese and Western are not enough. Third, this paper just shows some surface phenomenon and lack of deep analysis about why Japanese do not accept other country's game. Fourth, only formulating a reasonable price may not effectively improve the rampant piracy version, game industry personnel need more economy knowledge to make countermeasure. I believe the best way for Japanese game companies is to secure agent representation in China or cooperate with an existing Chinese firm.

Finally, Game refinement idea is a unique theory that has been proposed based on the uncertainty of game outcome. A game refinement measure was derived from the game information progress model and had been applied in the domains such as board games and sports games. According to the game refinement value we can judge any game how exciting or interesting it is. However, game refinement theory has one imperfection, some similar exciting level games have the completely different population of fans and players. In order to solve the problem, we need base on the game refinement theory to expand a new mathematical model to explain the paradox phenomena in the future. Also I will do more research about opening strategy in Non-random incomplete information game.

Publications and Conference

Journal Articles

XIONG Shuo. (2013). The Japanese and Chinese Game Secluding From the Outside World and countermeasure for dealing with the situation. Japan digital games annual conference 2012. 066–075

Shuo XIONG (2014). The Problems With Modern Japanese and Chinese Game Seclusion From the Outside World and In-depth Analysis of the Countermeasures, Journal of US-China Public Administration, 11(4): 334-344.

Shuo XIONG, Long ZUO, H. Iida. Quantifying Engagement of Electronic Sports Game, International Conference on Social Sciences Research (SSR2014), Hong Kong, (December, 2014)

International Conferences

Shuo XIONG. The Problems With Modern Japanese and Chinese Game Seclusion From the Outside World and In-Depth Analysis of the Countermeasures, International Conference on Japan Game Studies 2013, Kyoto, Japan (May, 2013)

Shuo XIONG. The Classic board game history - Asian Modern Game "Sakoku" problem and its counter measures, The 8th International Conference on Computers and Games (CGIW2013): Computer Games and Intelligence Workshop, Yokohama, Japan (August, 2013)

Shuo XIONG and H. Iida. The depth studies of game knowledge sharing and Asian game market, Replaying Japan Again: 2nd International Japan Game Studies Conference, Edmonton, Canada (August, 2014)

Shuo XIONG, and H. Iida. Attractiveness of Real Time Strategy Games, International Conference on Systems and Informatics (ICSAI 2014), IEEE, Shanghai, China (November, 2014)

Shuo XIONG, Long ZUO, H. Iida. Quantifying Engagement of Electronic Sports Game, International Conference on Social Sciences Research (SSR2014), Hong Kong, (December, 2014)

Domestic Conference

XIONG Shuo. (2013). The Japanese and Chinese Game Secluding From the Outside World and countermeasure for dealing with the situation. Japan digital games annual conference 2012. 066–075

Shuo XIONG, Long ZUO, R. Chiewvanichakorn and H. Iida. Quantifying Engagement of Various Games, 19th Game Programming Workshop (GPW-14), Hakone, (November 2014)

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