Tamkang University

Department of Innovative Information and Technology

==

105 Academic Year Monograph Written Report

天才麻將少年少女

The Genius of Mahjong Boys and Girls

Committee Members of Oral Defense

Chair：________________

____

____

____

Date：Jan 04, 2017

授權書

茲授權淡江大學資訊創新與科技學系將本人於淡江大學發表之畢業專題，以電子出版品方式發行，例如將著作儲存於光碟，以光碟形式發行，或與電腦網路連結，提供讀者基於個人非營利性質之線上檢索、閱讀、列印等，得不限時間與地域，為學術研究目的之利用。

授權範圍：全部授權。

*立授權書人聲明並保證對上述授權之著作擁有著作權，得為此授權。唯本授權書為非專屬性之授權，立授權書人對上述授權之著作仍擁有著作權。

*上述授權內容均無須訂立讓與及授權契約書。依本授權之發行權為非專屬性發行權利。依本授權所為之收錄、重製、發行及學術研發利用均為無償。

*立授權書人聲明並保證上述於淡江大學發表之畢業專題所做的一切行為負責，並保證遵守中華民國相關著作權法及一切國際著作權法的規定及慣例。

學號：402840275

授權人：陳浩瑜　(簽名)

===

學號：402844020

授權人：姚遠鳴　(簽名)

===

學號：402840135

授權人：楊紫伶　(簽名)

===

學號：402840457

授權人：陳主恩　(簽名)

===

中華民國106年1月4日

摘要

麻將在中華文化中佔有非常重要的地位，是臺灣人逢年過節不可或缺的娛樂活動，能活化思路、幫助思考。由於科技發達、網路普及的現在，越來越多人使用電腦或行動裝置玩麻將遊戲，因此，在本論文將討論電腦麻將遊戲的人工智慧開發，演算法的運用。透過設計不同等級的人工智慧，與不同等級之人工智慧的電腦玩家對戰。進行人工智慧研發的時候，我們思考了許多不同棄牌的思路，然後試著量化一個新手麻將玩家到老手玩家思路模式的不同，也讓這些不同思路的人工智慧進行了一百萬次以上大量的模擬對戰，進而比對出人工智慧之間的優劣以及特性。設計完人工智慧的架構後，我們也以這些人工智慧為基底，利用 Java 設計出一款單人的麻將遊戲，中間過程包含了使用者介面的設計、麻將圖片的繪製。可以藉由使用者介面的輔助，跟電腦進行麻將對戰。

Abstract

Mahjong has an important stand in the Chinese culture, and it is also one of the entertainment activities for Taiwanese people celebrating festival. Due to the advance of technology and the popularity of network, people play Mahjong through computer or the mobile devices. We will discuss the artificial intelligence development of Mahjong game on computer and the application of algorithm. Through design different level of artificial intelligence, battle with different artificial intelligence. During the research, we thought lots of different thoughts, then tried to quantify the different thought of player from a beginner to old hand. Also, let these artificial intelligences to do simulate battle one million times, and compare pros and cons and characteristics. After designing the architecture of artificial intelligence, we make a use of Java to design a single player mahjong game based on these artificial intelligences. Includes user interface design, mahjong picture drawing. We can battle with computer via assisting by user interface.

致謝

能夠完成這項專題研究，一定要先感謝我們的指導教授洪復一老師在這半年的指導與提點。在這半年中，老師每一週撥空與我們面談，檢討我們論文以及簡報上的錯失，還有提供各種意見。更為了我們的生涯規劃，給予了許多建議，真的非常感謝老師。不只是專題指導教授，也很感謝在校園裡的其他老師於平日在課堂或是課外的指導。當然專題組員們也是這個專題研究中不可或缺的一份子。雖然大家擁有的能力不盡相同，但是卻可以從中互補，可以足足的感受到團隊合作力量的強大。最後謝謝評審老師可以點出我們這次研究的各種缺失，不經一事不長一智，被點出的缺失會使我們成長，讓未來的我們可以更有能力。

Table of Contents

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Motivation

Every Chinese festival, family get together to play Mahjong is one of the folk entertainment in Taiwan. Though the government used to regard playing Mahjong as an act of gambling in the period of 1950~1987, Mahjong is considered as a good game after the end of Martial Law as civic literacy increases. Also, playing Mahjong is able to promote brainstorming to prevent dementia. Nevertheless, with the advance of technology and the popularity of network, most people playing Mahjong game through the computers and smartphones, especially the youngster. Nowadays, Mahjong games tend to from single user game to online game in game markets. According to the Mahjong researcher, Duan Hao (2016), he mentioned that "people devote to Mahjong artificial intelligence (AI) research is not enough." [3] Therefore, we decide to design a single user game of Mahjong AI by programming Java.

1.2 Purpose

With the development of science and technology toward AI, we expected The Genius of Mahjong Boys and Girls (GMJBG) not only could divide into different AI rank from human's thinking model such as the way of playing Mahjong of the beginner and the old hand, but it also could design a sets of Mahjong AI algorithms based on elementary, intermediate and advanced.

The goal of this project is to research AI's thinking in Mahjong game, and achieve a single player can simply play Mahjong game with other three computers AI of different levels. The player also can enjoy this Mahjong game on the computer without the network. In addition, we almost created a game engine by means of using Java's Abstract Window Toolkit (AWT), Java Swing and Photoshop.

1.3 Related Information

In the field of artificial intelligence, computer game is a very important part. In addition to the variety of bondage games from AI development such as double, multiplayer battle game, and there are a variety of puzzle solving games, which are designed to make computer like a human player's behavior in a variety of the game. Many brand-new algorithms and data structures as these studies are proposed, and along with the modified algorithm and expert system, many games have gradually reached professional levels of artificial intelligence.

The computer game consists of full information and partial information, as well as the probability and non- probability. If the players can follow the situation on the scene to get information from each other, then the game is full information such as chess. On the other hand, if the players do not know the other players' cards, it belongs to partial information such as Texas Holdem Poker. However, the part of the probability and non- probability will depend on whether the game has mixed elements of probability to influence games such as Mahjong. The process from the beginning to end in a game, it mixed with the probability, and the player did not know the other players' tiles. Thus, it is a game of partial information.

Mahjong is a game that originated in China, was listed as the quintessence, and the game players are predominantly based on four people. In the countries of the world, they have developed their own rules, especially for calculating scoring and points, for example, Japan Mahjong has no flower tiles and the starting hand is 13 tiles. Although Mahjong game is a highly luck gambling game, it contains skill, strategy, and calculation. Furthermore, because of the diverse melds and the different combinations of Mahjong which can get different scores, it requires complex calculations and analysis. In the area of artificial intelligence research, Mahjong are classified as the official competition game by Taiwan Computer Game Association (TCGA), and Taiwanese Association for Artificial Intelligence (TAAI), and International Computer Games Association (ICGA). [7][8][9]

1.4 Thesis Architecture

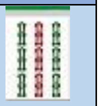
This thesis has five chapters, and it was organized as following. Chapter 1 talked about the thesis' motivation, purpose and related information. Chapter 2 introduced the overview and rule of Mahjong. Chapter 3 was the core of this thesis, it contained AI introduction, the computer AI of different levels in this system, system design, algorithm and system components. Chapter 4 showed the implementation of this Mahjong game system, including the user interface (UI) and the comparison diagram of different AI rank. Chapter 5 made a brief conclusion.

Chapter 2 Introduction of Mahjong

2.1 Thirteen Mahjong Overview

Through discard to make certain specific combination, and prevent opponents from achieving the same goal. The game is not only focus on skills, strategies and calculation, but also including the fortune. Thirteen Mahjong totally has 136 tiles (cards), and it has 4 identical copies of each simples tile and each honors tile. There are 3 different suits of simples and in each suit the tiles are numbered from 1 to 9. The suits are "Wan, Tong, Tiao" (「萬、筒、條」).

Table 1 Simples tiles of "Wan, Tong, Tiao"

		Numbers								
		1	2	3	4	5	6	7	8	9
Simples	Wan	一萬	二萬	三萬	四萬	伍萬	六萬	七萬	八萬	九萬
	Tong									
	Tiao									

Honors tiles are divided into wind tiles "East, South, West, North" (「東、南、西、北」) and dragon tiles(also called three elemental tile or arrow tiles) "Red, Green, White" (「中、發、白」). These tiles have no numerical sequence like the simples. [1][2]

Table 2 Winds of Honors tiles

Winds			
East	South	West	North
東	南	西	北

Table 3 Dragons of Honors tiles

Dragons		
Red	Green	White

2.2 The Rules of Thirteen Mahjong

Mahjong could be divided into two types, 13 tiles and 16 tiles, both of the rules are similar. This research only discussed 13 tiles in this paper. This is a 4-people game, and one of the players will be a dealer. If the dealer win, then continuing to be the dealer on the next play. If the drawn game happens, rotate the next player to be dealer. The games are usually ended after all players at least have been the dealer once.

The goal of the game is to make 14 tiles consists 4 melds of sequences (順子) or triplets (刻子), and 1 pair. Each of sequence and triplet is composed of 3 tiles, pair consists of 2 same tiles. A meld of sequence is made up of 3 continuous numbered tiles such as 1-Wan, 2-Wan, 3-Wan. A meld of triplet is made up of 3 same tiles.

From the beginning, only the dealer can take 14 tiles, others take 13 tiles. The dealer discard one of the most useless tiles, at the same time, all other 3 players have right to take that tile. The player on the next order of the dealer have right to chow (吃) or pong (碰), the other 2 players can only pong that tile. Chow, which means you want to complete one of the sequence and you already have 2 of them. Pong, which means you already have 2 of same tiles to complete the triplet, and you call it to complete your triplet. If the players call chow and pong at the same time, pong is the priority.Any of tiles that have chow and pong should be showdown, and cannot change it anymore. If someone discard a tile, but no one call chow or pong, then the next player can take one tile from the stack, which is called draw (摸牌). Whatever you chow, pong, or draw, you need to discard a tile that maintain you have 13 tiles.

When you make your own tiles to be a useful combination, and only need the fourteenth tile to win, then you are in the ready hand (聽牌) situation. Moreover, You can also make more than one possible combination that to be in the ready hand, increasing the chance of win. [1]

Chapter 3 System Analysis and Design

3.1 Artificial Intelligence

3.1.1 The Definition and Principle of AI

What is meant by AI? It is made out of artificial systems and then perform intelligent. Its definition can divide into two part, “Artificial” and “Intelligent.” Artificial means something can be manufactured by manpower, and whether the wisdom of the human themselves are high enough to create AI. When it defines the intelligent, the scientist of British, Turing (1950), made a huge contribution. If a machine can experiment through what is called Turing experiment, it is wise. The essence of the Turing experiment is that under the premise that people do not look at the appearance, people cannot distinguish between the behavior of the machine or human behavior, and then the machine is intelligent. [4]

In computer science, AI has received more and more attention and has been applied in the robot, economic and political decision-making, control systems and analog systems. Also, the main contents of AI research including knowledge representation, automatic reasoning and search methods, machine learning and knowledge acquisition, knowledge processing system, natural language understanding, computer vision, intelligent robot, automatic program design and so on.

The direction of AI research has been divided into several sub-areas, and an AI system should have some specific capabilities. [3]

The following are list of these capabilities and description:

1. Planning
   Intelligent agents must be able to set goals and implement these goals. They need a way to build a predictable world model, then you can choose the most effective behavior. However, the agent must periodically check whether the state of the world model is consistent with its own forecasts. If it does not, it must change its plan. Therefore, intelligent agents must have the ability to reason in the state of indeterminate results. In multi-agent, multiple agents plan to accomplish certain goals in a cooperative and competitive way. Using evolutionary algorithms and group intelligence can achieve an overall emergent behavioral goal.
2. Learning
   The main purpose of machine learning is to obtain knowledge from users and input data, which can help solve more problems, reduce errors and improve the

efficiency of problem-solving. For AI, machine learning is important from the beginning.

3. Natural Language Processing
   Natural Language Processing (NLP) refers to the language that allows computers to understand human beings.
4. Perception
   Machine perception refers to the ability to use input from sensor such as cameras, microphones, sonar and other special sensors, and then infer the state of the world. Also, computer vision can analyze image input.
5. Social intelligence
   Emotional and social skills are important for an intelligent agent. First, agents can predict the actions of others by means of understanding their motivations and emotional states. In addition, to make a good human-computer interaction, intelligent agents also need to show emotions. At least it must appear politely dealing with human beings, and it should have a normal mood.
6. Creativity
   A sub-field of AI addresses creativity both the theory, which from a philosophy and psychology perspective, and the reality, which via specific implementations of systems outputs that can be thought creative, or the system identifies and evaluates creativity. [5]

3.1.2 The Evolution of AI

About the evolution of artificial intelligence can be divided into the following four stages:

1. Budding period (1940-1950):
   The computer invented the first vacuum tube as the main computer came out. The computer master, Turing, proposed Turing Machine. The architecture and capacity constraints of today's computers is under this development; in this period the theorem show that the general problem-solving is the center of AI scholars. On the general problem, however, “because of too many search path, itself limits the speed of a computer, a number of heuristic search method only on paper” (Tong Guanye, 2002). This phase of AI researchers tried to build intelligent machines, that is, to make computers have the ability to think. Unfortunately, the development of software and hardware cannot catch up with AI that want to achieve the target.
2. Growth period (1960-1970):
   When developing AI language LISP, the robotics is attached important. Also,

the researches focus on making computers with the ability to understand, comparing the human nervous system with a computer. Hope that the effects on the human brain will be further understood, and study to replace the nervous system with the mechanical. There are many knowledge representation methods came out in this period, such as the semantic network and frame. Although these technologies about the machine's ability to understand didn’t have a breakthrough on development, they provided us the 1980's technology basis of the expert system.

3. Development period (1970-1980):

   Using predicate logic which developed the Prolog language has come out. Because of the human intelligence is so complex, it is staggered applying by means of thinking, learning, creating and associative analogies, making human easier than computers to solve general problems. Thus, in specific issue areas under full development of expert systems, AI obtained many positive results (Tong Guanye, 2002).

4. Application (1980-1999):

   Lenat who is the CEO of Cycorp embarked on the development of machine learning system. This system can automatically improve and extend its own by heuristics programming. In this period, various expert systems were developed, and the United States with strong financial and human resources, coupled with government attaches great importance to automation to improve productivity. There are hundreds of companies in the development of AI related products. [6]

3.1.3 The difference of AI Levels in GMJBG System

The figure 1 and figure 2 are the process from draw to discard. The main difference between our AI is the locking system. The locking system will affect the result of the game.

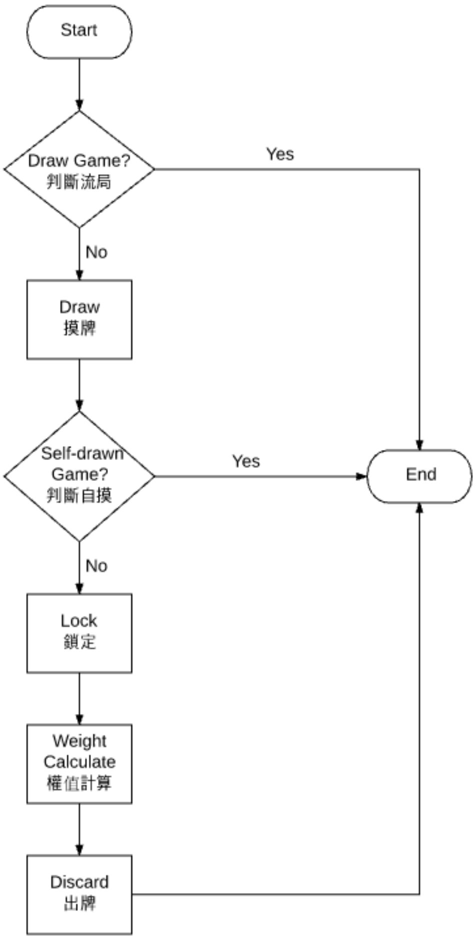


Figure 1 The Computer AI with Lock System

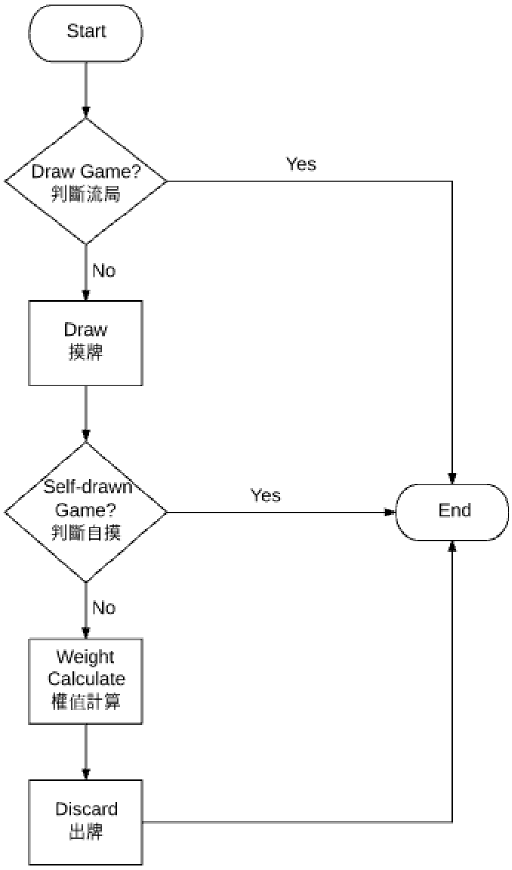
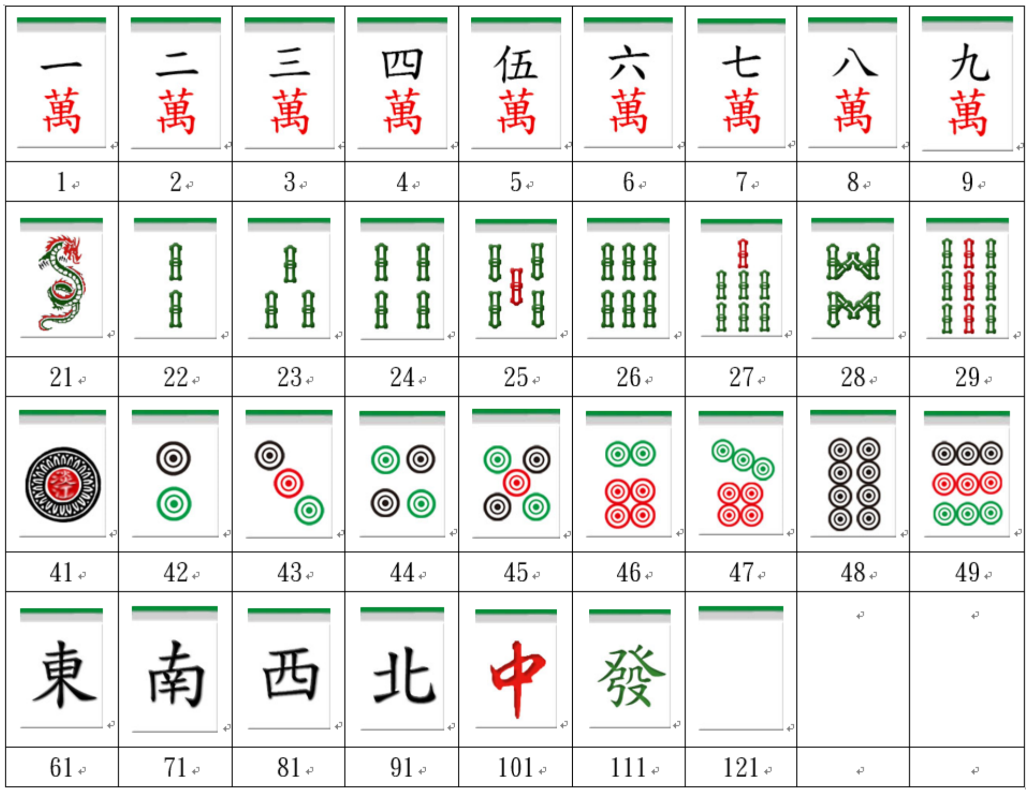


Figure 2 The Computer AI without Lock System

3.2 Mahjong Code

The figure 3 is the code of each Mahjong. GMJBG used these codes in the program with the simple and quick way to do analysis. [9] Because of this project's weight calculation is based on Mahjong coding system, when going on encoding Mahjong, it must separate the different types of mahjong codes to avoid the numbers are too close and cause different types of mahjong calculation occur the condition of addition weights.



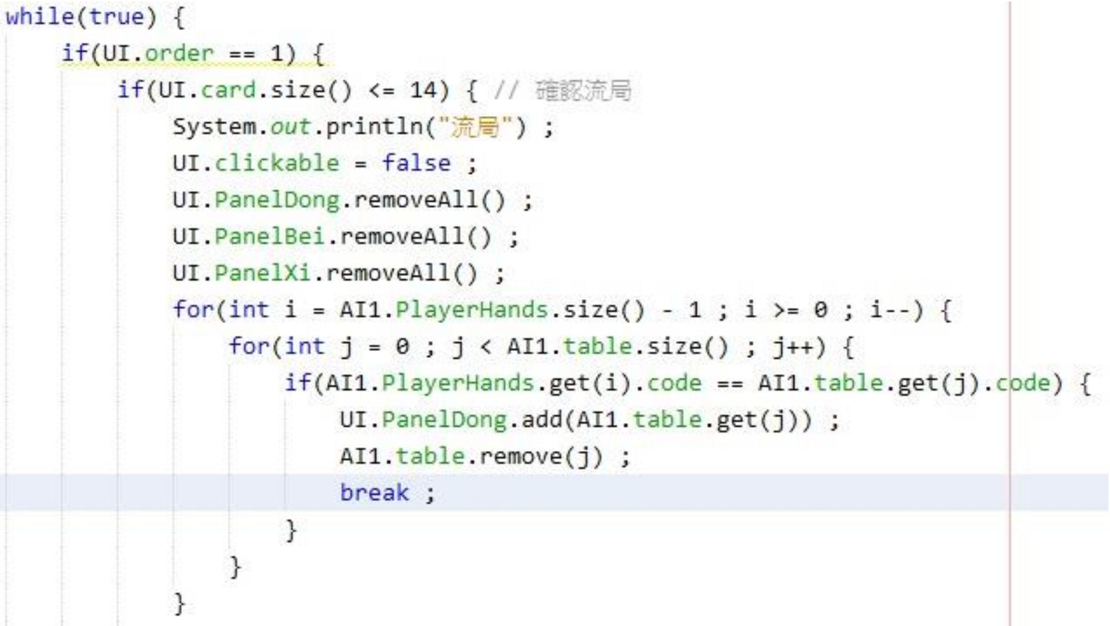
一萬	二萬	三萬	四萬	伍萬	六萬	七萬	八萬	九萬
1	2	3	4	5	6	7	8	9
21	22	23	24	25	26	27	28	29
41	42	43	44	45	46	47	48	49
東	南	西	北	中	發			
61	71	81	91	101	111	121		

Figure 3 Mahjong Encode Table

3.3 System Design

3.3.1 System Process

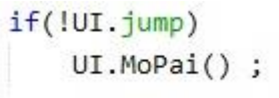
The whole game system process designed by these researchers consist of a few main parts.



```
while(true) {
    if(UI.order == 1) {
        if(UI.card.size() <= 14) { // 確認流局
            System.out.println("流局") ;
            UI.clickable = false ;
            UI.PanelDong.removeAll() ;
            UI.PanelBei.removeAll() ;
            UI.PanelXi.removeAll() ;
            for(int i = AI1.PlayerHands.size() - 1 ; i >= 0 ; i--) {
                for(int j = 0 ; j < AI1.table.size() ; j++) {
                    if(AI1.PlayerHands.get(i).code == AI1.table.get(j).code) {
                        UI.PanelDong.add(AI1.table.get(j)) ;
                        AI1.table.remove(j) ;
                        break ;
                    }
                }
            }
```

Figure 4 Detection of the draw game (流局)

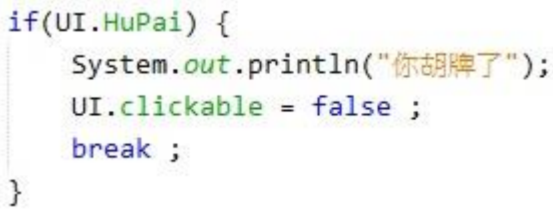
Checking "order" firstly, this parameter indicates which players turn to discard, and then check whether to happen the draw game. If you did not touch the cards left on the table is less than or equal to 14 tiles, it means the draw game. After drawing, the window will directly display all player hands.



```
if(!UI.jump)
    UI.MoPai() ;
```

Figure 5 Jump draw card process

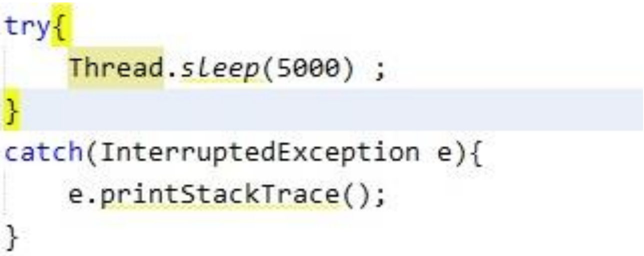
In the figure 5, if it happens the conditions of "chow", "pong", "kong"（槓）, then this parameter "jump" will be changed, and jumping to occur the action of a player's location and let this player proceed to draw.



```
if(UI.HuPai) {
    System.out.println("你胡牌了");
    UI.clickable = false ;
    break ;
}
```

Figure 6 Check winning

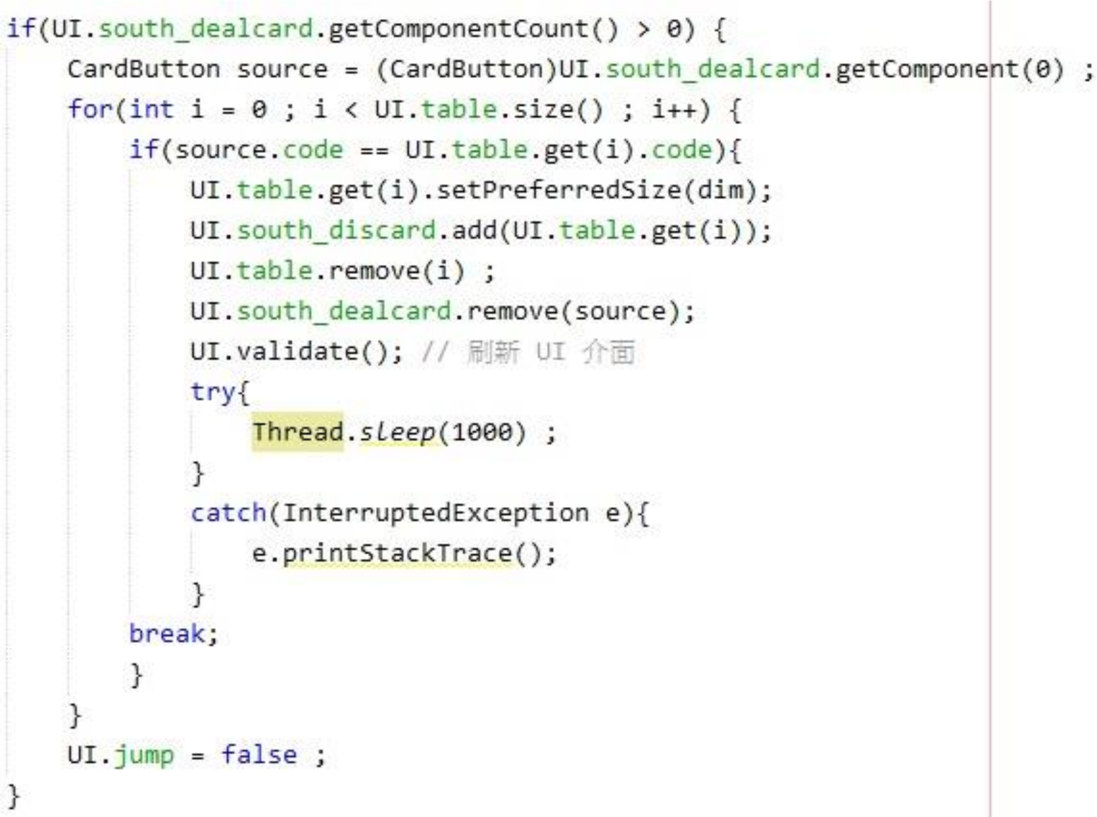
The figure 6 is about to check the winning. If you win, it will inform this system to end the game.



```
try{
    Thread.sleep(5000) ;
}
catch(InterruptedException e){
    e.printStackTrace();
}
```

Figure 7 Wait for user action

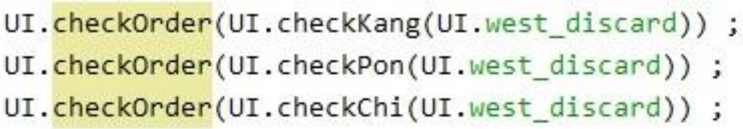
From this figure 7, if none of the above-mentioned situations occur, then the program suspended for five seconds, and giving players to discard.



```
if(UI.south_dealcard.getComponentCount() > 0) {
    CardButton source = (CardButton)UI.south_dealcard.getComponent(0) ;
    for(int i = 0 ; i < UI.table.size() ; i++) {
        if(source.code == UI.table.get(i).code){
            UI.table.get(i).setPreferredSize(dim);
            UI.south_discard.add(UI.table.get(i));
            UI.table.remove(i) ;
            UI.south_dealcard.remove(source);
            UI.validate(); // 刷新 UI 介面
            try{
                Thread.sleep(1000) ;
            }
            catch(InterruptedException e){
                e.printStackTrace();
            }
        break;
        }
    }
    UI.jump = false ;
}
```

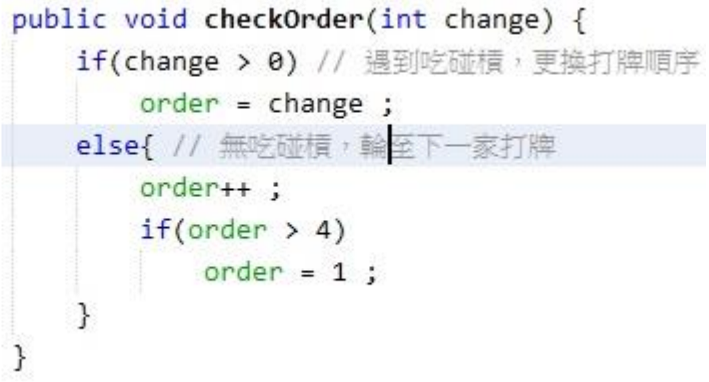
Figure 8 Over time, automatically discard the rightmost tile

The code about the figure 8 explains that if the player doesn’t respond, then it will automatically discard the rightmost card.



```
UI.checkOrder(UI.checkKang(UI.west_discard)) ;
UI.checkOrder(UI.checkPon(UI.west_discard)) ;
UI.checkOrder(UI.checkChi(UI.west_discard)) ;
```

Figure 9 Checking “chow”, “pong”, “kong”



```
public void checkOrder(int change) {
    if(change > 0) // 遇到吃碰槓，更換打牌順序
        order = change ;
    else{ // 無吃碰槓，輪至下一家打牌
        order++ ;
        if(order > 4)
            order = 1 ;
    }
}
```

Figure 10 Player discard order control

Finally, the main feature of this function in the figure 10 is to change the positions of the discard when occurring “chow”, “pong”, “kong.”

3.3.2 Weight System

The weight system divided into the following two parts: basic weight and addition weight. The actual weight of a tile is based on the sum of basic weight and addition weight.

3.3.2.1 Basic Weight

When defining each of basic weight to tiles, we divided tiles into four types: honor tiles, simples tiles numbered one and nine, simples tiles numbered two and eight, and simples tiles numbered three to seven. Because honor tiles cannot make the sequence, we use its basic weight to set the smallest value, zero.

For the simples tiles numbered one and nine, because it only has one separated and neighbored situation, we also set the weight to zero.

For the simples tiles numbered two and eight, it has two situation of neighbor, but only one situation in separated, therefore, we set the weight to one.

For the simples tiles numbered from three to seven, because it has two separated and two neighbored situations, we set the weight to two.

3.3.2.2 Addition Weight

To define addition weight, it is based on the combination of mahjong to set four types of addition weight. First, separated, if two tiles separated; there is only one valid tile, so set the weight to one. If two tiles neighbored, there are two valid tile. For the identical tiles, divided into the same of two and the same of three. For the same of two, it could be pair and it could also pong (碰) a tile to be a triplet, so set the weight to two. For the same of three, it has been already a set of triplet, it could also kong (槓), so set the weight to four.

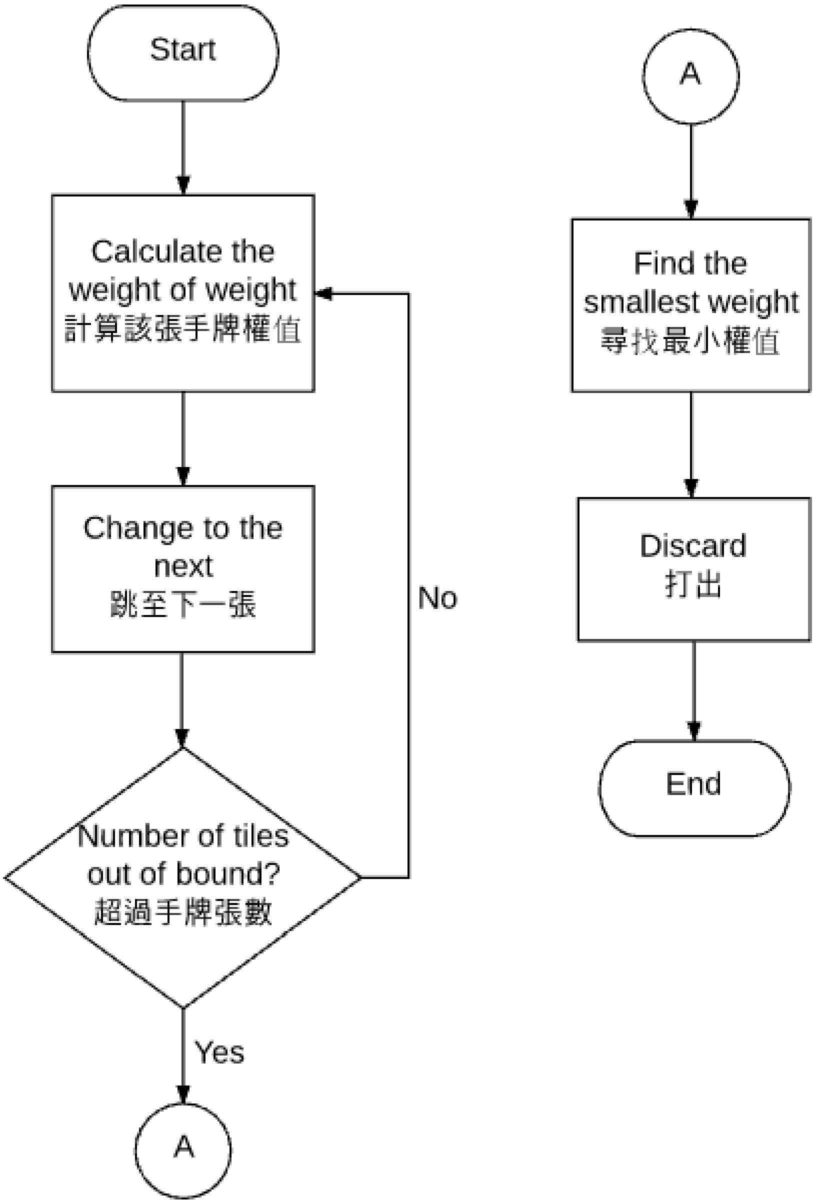


Figure 11 Find the tile which has the smallest weight

3.3.3 Consider the special combination (Three Orphans)

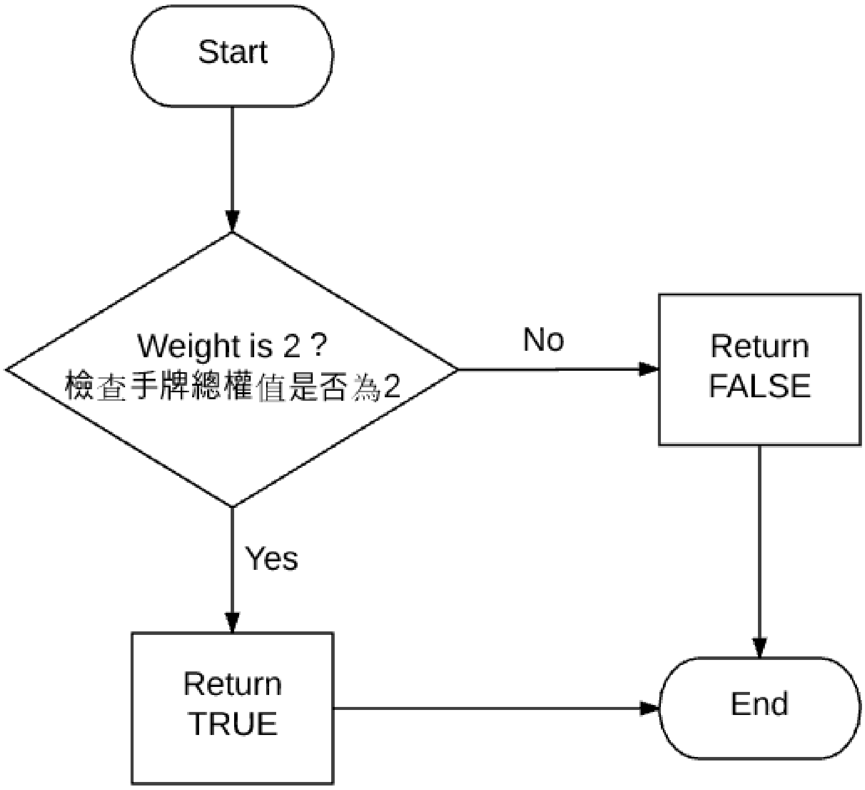


Figure 12 Three Orphans check

Simples tiles numbered one and nine and honor tiles for each, then add one of any. Through calculation, basic weight is zero and only one pair, so the addition weight is two. The total weight is two, which means this is thirteen orphans combination.

3.3.4 Locking Tiles System

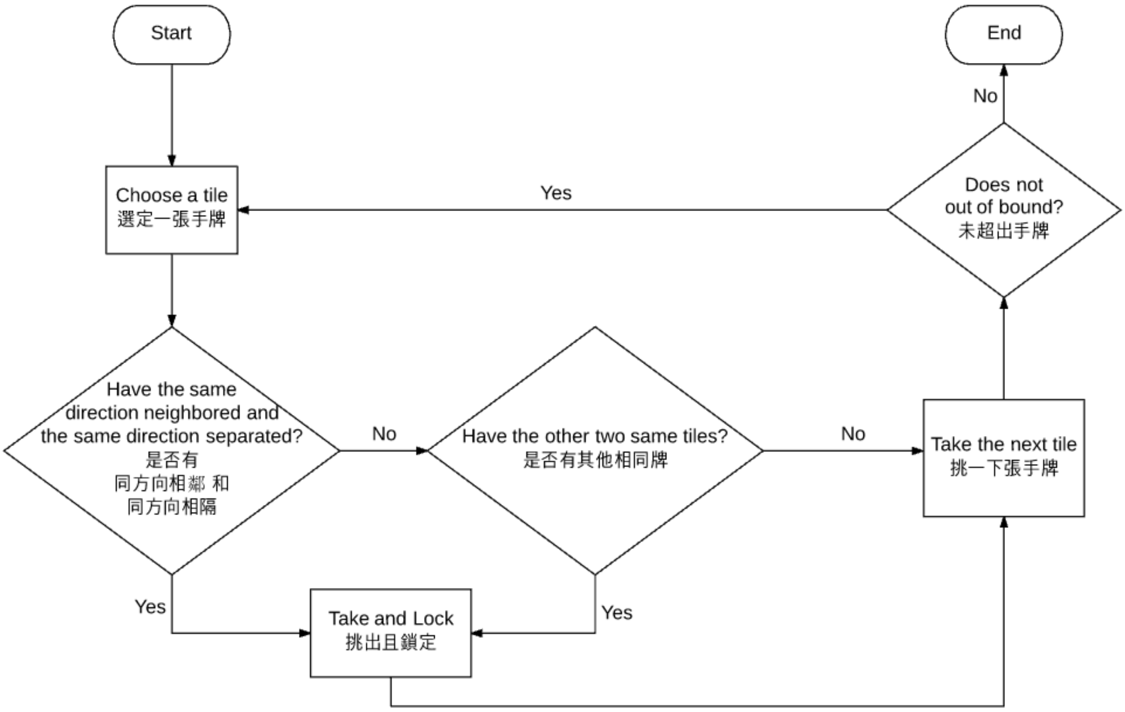
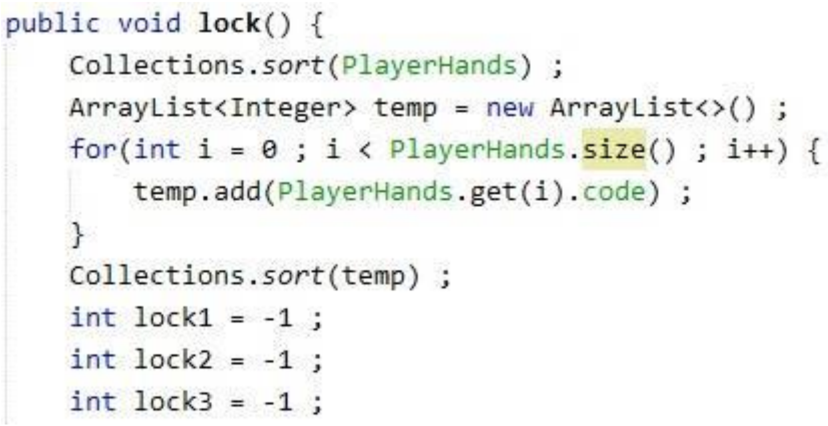


Figure 13 Locking system

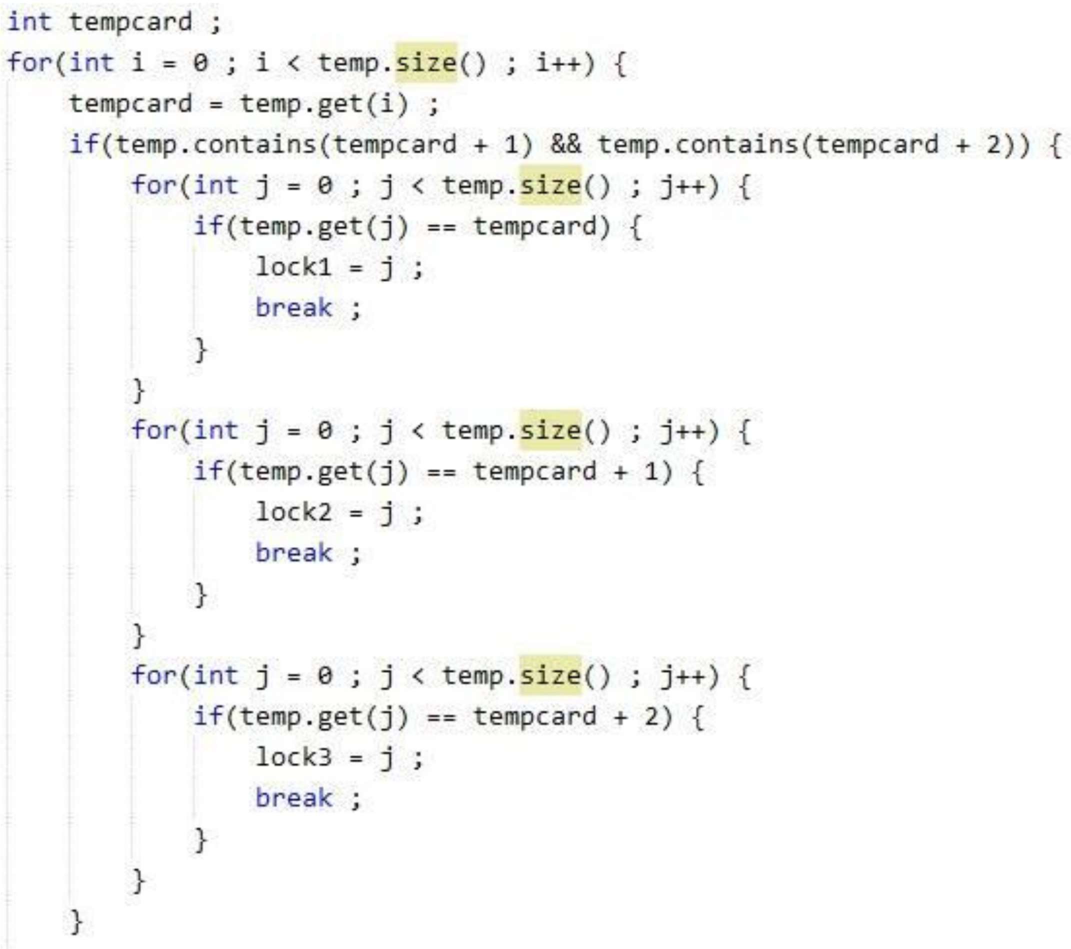
While design artificial intelligence discard strategy, we found an algorithm which is more effective than the original method of weight calculation.



```
public void lock() {
    Collections.sort(PlayerHands) ;
    ArrayList<Integer> temp = new ArrayList<>() ;
    for(int i = 0 ; i < PlayerHands.size() ; i++) {
        temp.add(PlayerHands.get(i).code) ;
    }
    Collections.sort(temp) ;
    int lock1 = -1 ;
    int lock2 = -1 ;
    int lock3 = -1 ;
```

Figure 14 Code of locking system

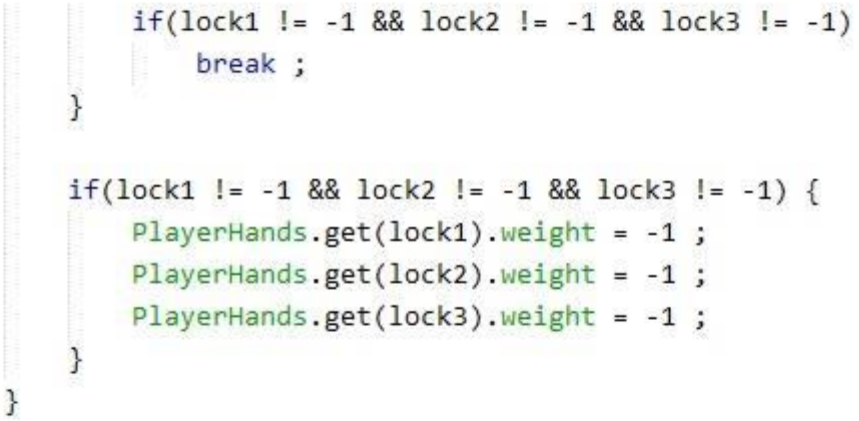
This function will directly make a set of sequence to be -1. Then create a new temp ArrayList to store the code of PlayerHands.



```
int tempcard ;
for(int i = 0 ; i < temp.size() ; i++) {
    tempcard = temp.get(i) ;
    if(temp.contains(tempcard + 1) && temp.contains(tempcard + 2)) {
        for(int j = 0 ; j < temp.size() ; j++) {
            if(temp.get(j) == tempcard) {
                lock1 = j ;
                break ;
            }
        }
        for(int j = 0 ; j < temp.size() ; j++) {
            if(temp.get(j) == tempcard + 1) {
                lock2 = j ;
                break ;
            }
        }
        for(int j = 0 ; j < temp.size() ; j++) {
            if(temp.get(j) == tempcard + 2) {
                lock3 = j ;
                break ;
            }
        }
    }
```

Figure 15 Find the tile which need to be locked

Use this variable “tempcard” to store the code, find the index then store to three constant.



```
        if(lock1 != -1 && lock2 != -1 && lock3 != -1)
            break ;
    }

    if(lock1 != -1 && lock2 != -1 && lock3 != -1) {
        PlayerHands.get(lock1).weight = -1 ;
        PlayerHands.get(lock2).weight = -1 ;
        PlayerHands.get(lock3).weight = -1 ;
    }
}
```

Figure 16 Set the basic weight to -1

Check whether three constant will change or not, if change make the weight to be -1.

3.3.5 Chow, Pong, Kong Determination

We can by use of locking system to do chow, pong, kong determination. The main purpose is to make sure whether others' discard is the valid tiles. Theory is to calculate the total weight, compare tiles of chow and pong put them into tiles, then calculate the total weight again. Because of the characteristic of locking system, the tiles which has been already made a combination would be ignore because of the locking system. Therefore, if the tiles that chow and pong is valid, the total weight would decrease, but kong would not increase the rate of draw, we won't discuss it here.

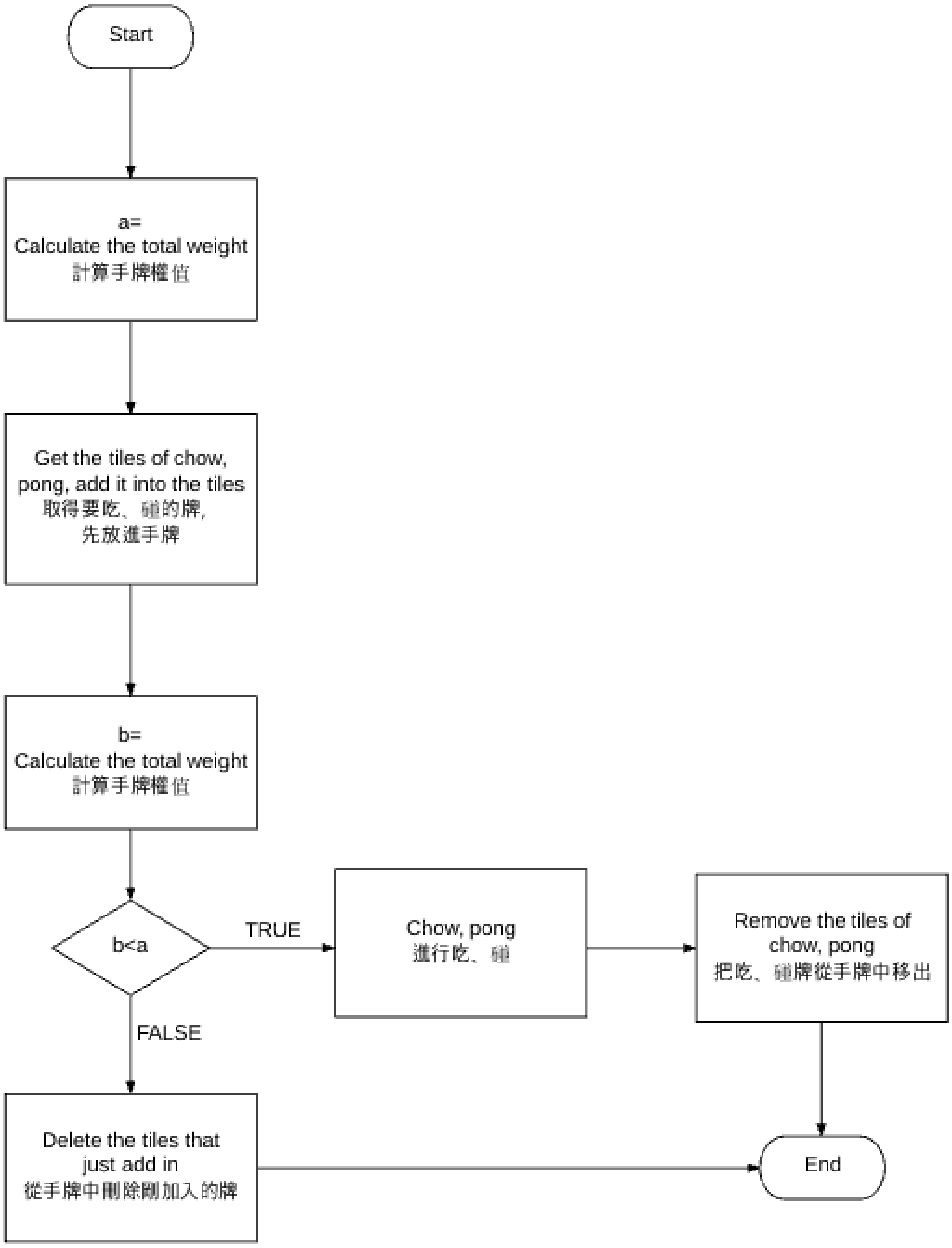
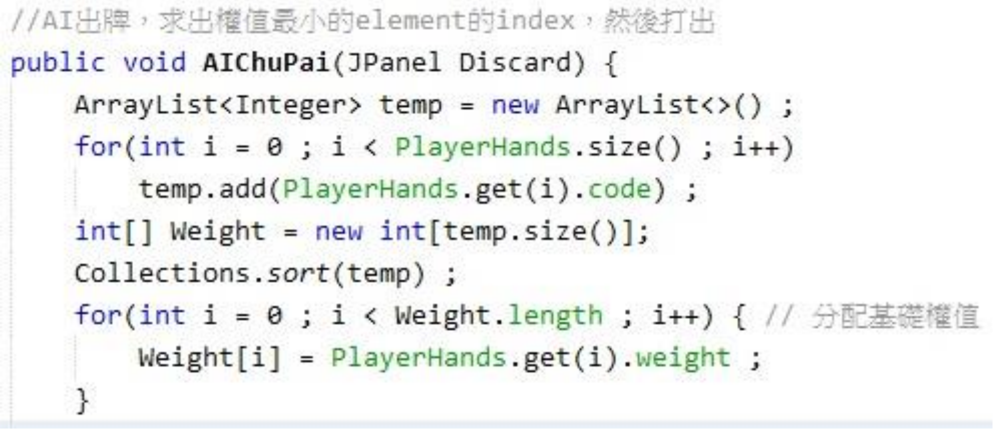

Start
a=
Calculate the total weight
計算手牌權值
Get the tiles of chow, pong, add it into the tiles
取得要吃、碰的牌,
先放進手牌
b=
Calculate the total weight
計算手牌權值
b<a
TRUE
Chow, pong
進行吃、碰
Remove the tiles of chow, pong
把吃、碰牌從手牌中移出
FALSE
Delete the tiles that just add in
從手牌中刪除剛加入的牌
End

Figure 17 Chow, Pong, Kong

3.4 Improved Greedy Algorithm

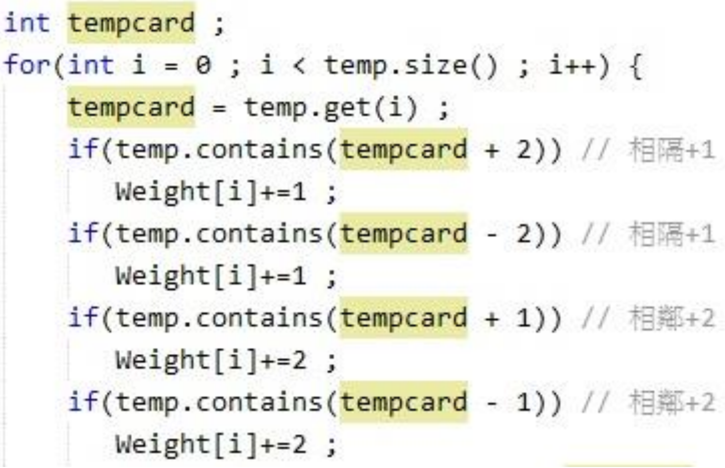
The AI Mahjong discard algorithms of this system, GMJBG, is based on the weight system of the improved greedy algorithm. The input is a set of 14 tiles allocated of the basic weights, calculating addition weights, then discarding the minimum weight tile.



```
//AI出牌，求出權值最小的element的index，然後打出
public void AIChuPai(JPanel Discard) {
    ArrayList<Integer> temp = new ArrayList<>() ;
    for(int i = 0 ; i < PlayerHands.size() ; i++)
        temp.add(PlayerHands.get(i).code) ;
    int[] Weight = new int[temp.size()];
    Collections.sort(temp) ;
    for(int i = 0 ; i < Weight.length ; i++) { // 分配基礎權值
        Weight[i] = PlayerHands.get(i).weight ;
    }
```

Figure 18 Load the basic weight from each tile

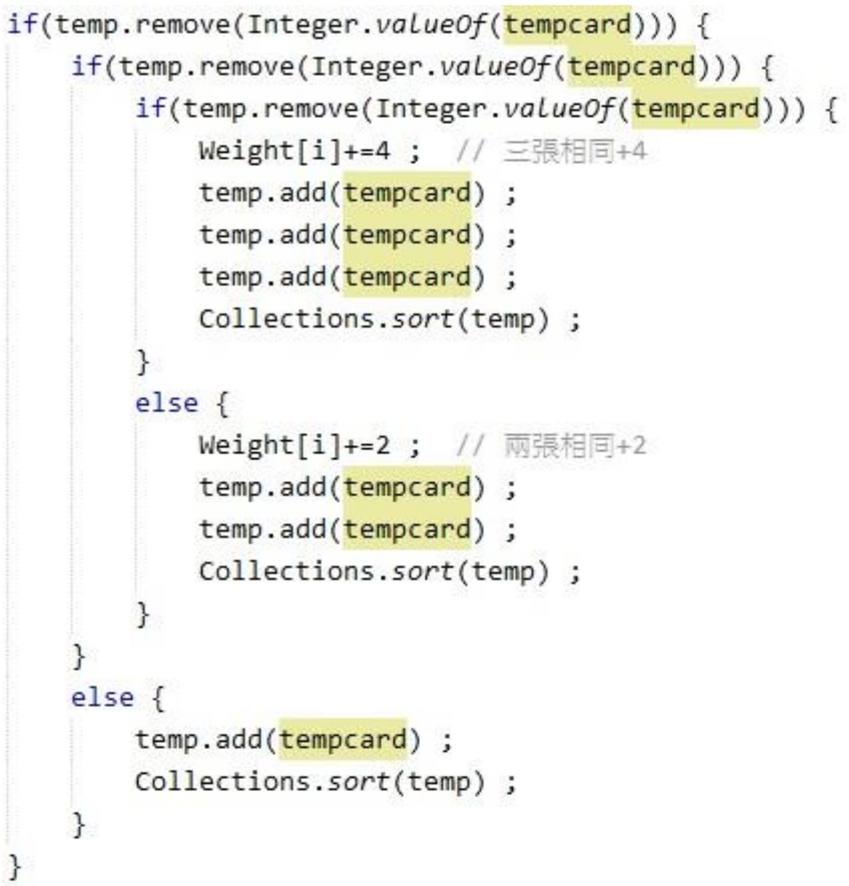
In this figure 18, the name of this function is AIChuPai() and type is void, the input of this function is a JPanel which contains 14 CardButton objects, first we colon these objects to a new ArrayList named temp, and create a new array Weight to sort the weight of the CradButton. Then, collecting the temp ArrayList. Lastly, assign the basis weights to the Weight array.



```
int tempcard ;
for(int i = 0 ; i < temp.size() ; i++) {
    tempcard = temp.get(i) ;
    if(temp.contains(tempcard + 2)) // 相隔+1
        Weight[i]+=1 ;
    if(temp.contains(tempcard - 2)) // 相隔+1
        Weight[i]+=1 ;
    if(temp.contains(tempcard + 1)) // 相鄰+2
        Weight[i]+=2 ;
    if(temp.contains(tempcard - 1)) // 相鄰+2
        Weight[i]+=2 ;
```

Figure 19 Calculate the addition weight of neighbor and separate

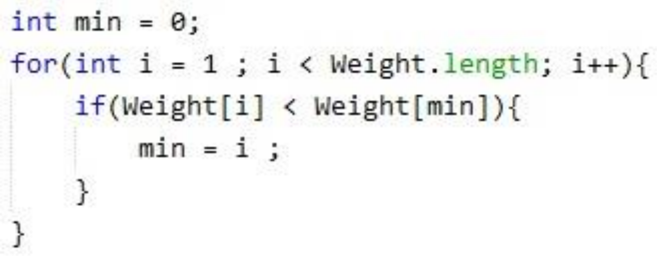
The figure 19 is based on the weight system to calculate the addition weights of neighbor and separation.



```
if(temp.remove(Integer.valueOf(tempcard))) {
    if(temp.remove(Integer.valueOf(tempcard))) {
        if(temp.remove(Integer.valueOf(tempcard))) {
            Weight[i]+=4 ;  // 三張相同+4
            temp.add(tempcard) ;
            temp.add(tempcard) ;
            temp.add(tempcard) ;
            Collections.sort(temp) ;
        }
        else {
            Weight[i]+=2 ;  // 兩張相同+2
            temp.add(tempcard) ;
            temp.add(tempcard) ;
            Collections.sort(temp) ;
        }
    }
    else {
        temp.add(tempcard) ;
        Collections.sort(temp) ;
    }
}
```

Figure 20 Calculate the addition weight of the same of two and the same of three

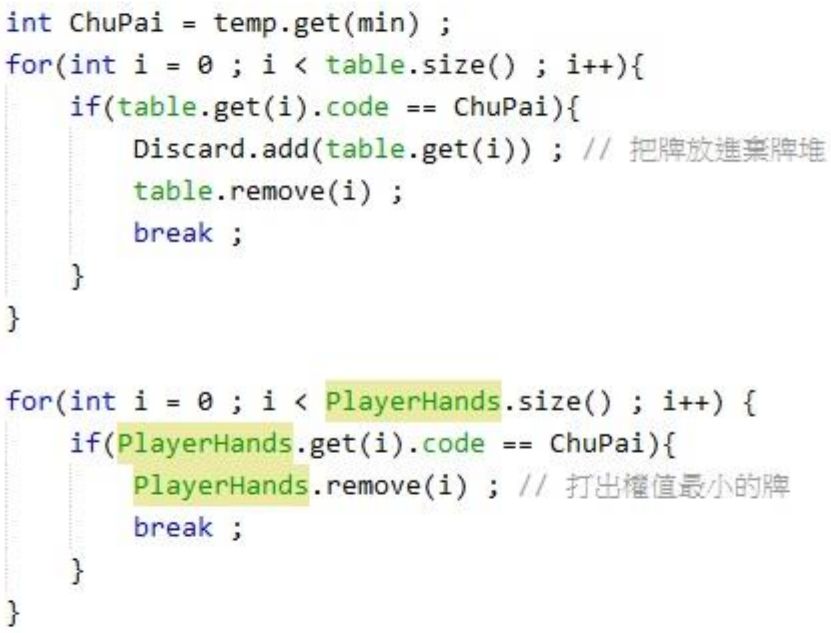
According to the weight system above of the figure 20 is to calculate the same Mahjong’s addition weights. Because of two situations for the same addition weights, we need to check whether the three tiles are same. If the three tiles are not the same tiles, it will be the two same tiles.



```
int min = 0;
for(int i = 1 ; i < Weight.length; i++){
    if(Weight[i] < Weight[min]){
        min = i ;
    }
}
```

Figure 21 Find the smallest one

In the figure 21, finding the minimum weight value of the object’s index from Weight array.



```
int ChuPai = temp.get(min) ;
for(int i = 0 ; i < table.size() ; i++){
    if(table.get(i).code == ChuPai){
        Discard.add(table.get(i)) ; // 把牌放進棄牌堆
        table.remove(i) ;
        break ;
    }
}

for(int i = 0 ; i < PlayerHands.size() ; i++) {
    if(PlayerHands.get(i).code == ChuPai){
        PlayerHands.remove(i) ; // 打出權值最小的牌
        break ;
    }
}
```

Figure 22 Discard the tile which has the smallest weight

From the figure 22, firstly, we place tiles in the discard pile named Discard, and then remove it from the hand called PlayerHands, completing the action of discarding and put the tile in the table.

3.5 System Components

In this project, we used the following software components (e.g. Java, Java AWT, Java Swing, NetBeans, Photoshop) to construct a Mahjong game system, and these software components are introduced below:

3.5.1 Java

Java is a way to write cross-platform applications of object-oriented programming language. Java programming language's style is very close to the C++ language, inherited the core C++ language object-oriented technology and Java get rid of C++ language which likely to cause an error pointer, operator overloading, multiple inheritance and so on. Java added function for recycling garbage collector is no longer referenced internal memory space occupied by the object. Thus, Java was developed to achieve the following five objectives:

1. Using object-oriented programming methodology.

2. Allowing the same program on different computer platforms to perform.

3. Including the built-in support for computer networks.

4. It is designed to securely perform remote program code.

5. It is easy to use, and learning the strengths from previous object-oriented language such as C++.

In this project, we not only use java programming language, but they also use Abstract Window Toolkit (AWT) and Swing. Both of two suites are from Java API, and we can make graphical user interface (GUI) from Java AWT and Java Swing.

The difference of two suites is that AWT used operating system (OS) which provided Windows component, so using AWT window designed by a graphics program will be consistent with the operating system, Windows. Java Swing is to use native Java program code to draw the window component, so there is no difference in appearance between the various platforms by using Java Swing. [10] [11]

3.5.1.1 Java AWT

AWT (Abstract Windowing Toolkit), is provided to set up and the basic tools of the Java graphical user interface. Java.awt package in Java AWT provided, which contains a lot of graphics that can be used to create platform-independent GUI classes, and these classes are called components. There are Java platform-independent window system, graphics and user interface toolkit in AWT. AWT is a part of Java foundation classes (JFC) for Java program which provides a GUI of the standard API.

AWT provides the basic components of available GUI in Java Applet and Java Application. Since Java is a programming language of platform-independent, but the GUI is often tied to a particular platform. Therefore, Java adapts to the technique to make AWT provide platform-independent interface to the application, and this ensures that the same program GUI running on different machines with similar-looking. AWT is the API for Java programs to provide the GUI toolkits, and AWT can be used in Java applet and applications. [11] [12]

3.5.1.2 Java Swing

Java Swing is a part of Java foundation classes (JFC), and it is a try to solve the shortcomings of AWT. Relative to AWT, Swing is the lightweight components. Swing and AWT are purely written in Java, and they can run cross-platform. They are part of JFC. They support the replaceable perceptions and topics. However, Swing is not true to use the native platform provided equipment, but just imitate them on the surface. This means that you can use Java on any platform supported by any perception. Disadvantage of the lightweight components is that the execution speed is slow. In Java Swing, Java develops a carefully designed, flexible, and powerful GUI toolkit, and it use a model view controller (MVC) pattern, which greatly increases the flexibility of Swing. [12]

3.5.2 NetBeans

NetBeans includes the development environment of open source and application platform, NetBeans IDE enables developers to use the Java platform to rapidly create Web, Enterprise, desktop, and mobile applications. NetBeans IDE has already supported PHP, Ruby, JavaScript, Groovy, Grails and C/C++ development language. NetBeans project is sustained by an active development community, and NetBeans development environment provides the extensive product documentation and training resources, as well as a large number of third-party plugins.

NetBeans is a development integrated environment of the open source software, and it is an open framework, an extensible development platform can be used in Java, C/C++, PHP, and so forth. Also, NetBeans itself is a development platform which can be extended through plug-ins to extend functionality.

In NetBeans platform, the application software is to use a series of modular software components to be constructed. These modules are the jar file (Java Archive File), which contains a set of Java programs category, and their implementation is based on the NetBeans public interface and a range of used to distinguish the different module manifest file. Therefore, depending on the benefits of the modular, with modules to build application only need to add the new modules and they can be further expanded. [13]

3.5.3 Photoshop

Photoshop specializes in image-processing software from Adobe company, the main application areas include graphic design, pre-press layout, Web design, video editing, 3D animation, and so on. Currently, Photoshop in the most popular items on the market are using image-processing software in image editing, or whatever draws a synthesis. It has broken down the various tools and related numerical set of panels, allowing the user to do the most precise adjustments; furthermore, the powerful filter feature is one not to be missed, various filter effects can simulate realistic images. [14]

Chapter 4 Implementation

4.1 User Interface

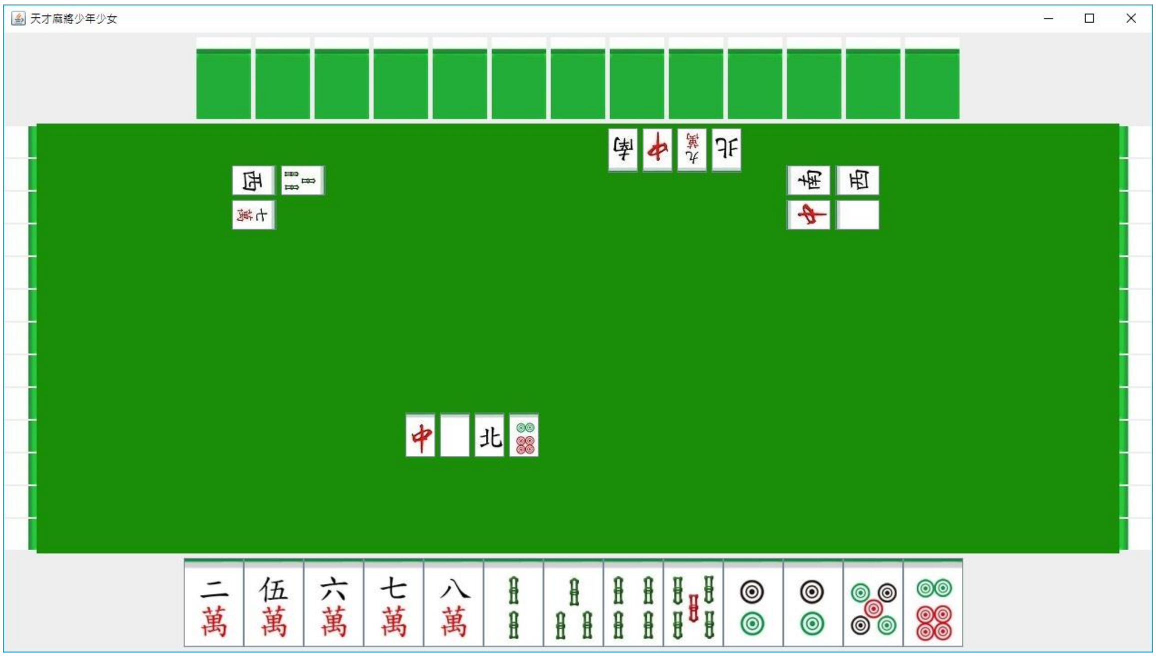


Figure 23 User Interface

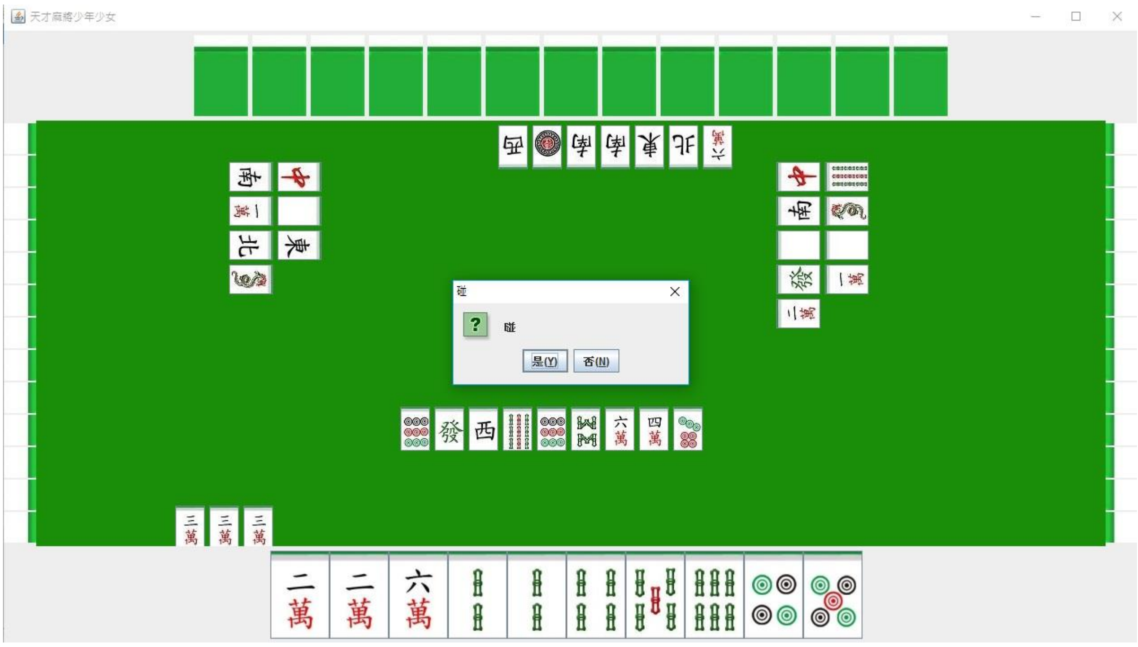


Figure 24 “chow”, “pong”, “kong”

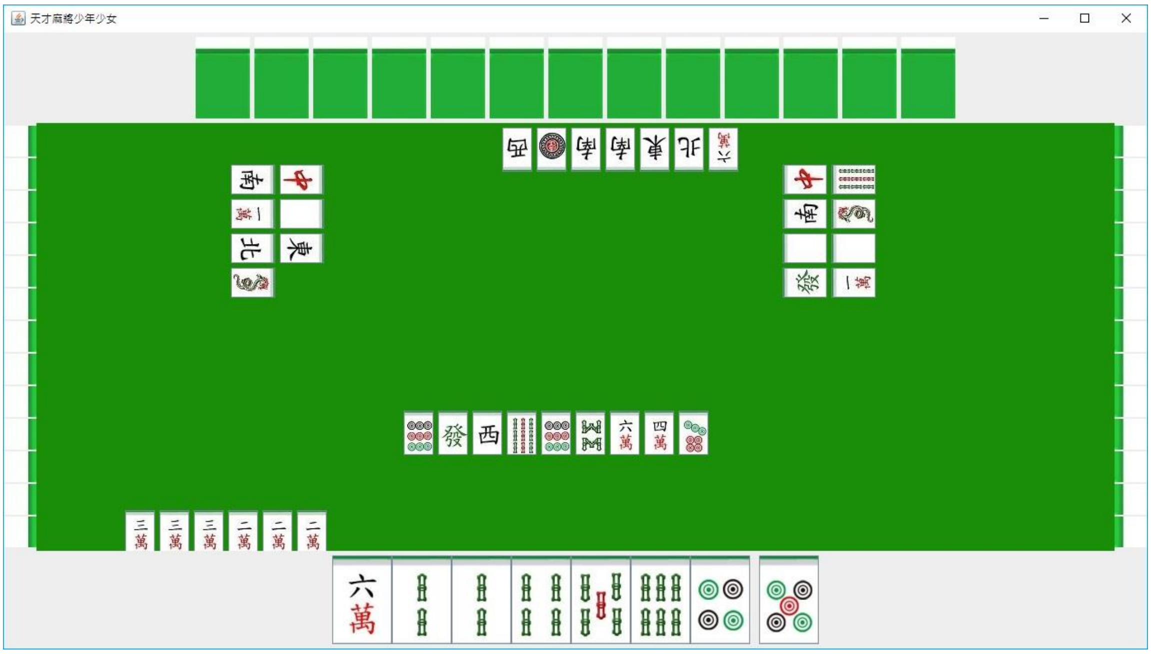


Figure 25 After chow, pong, kong process

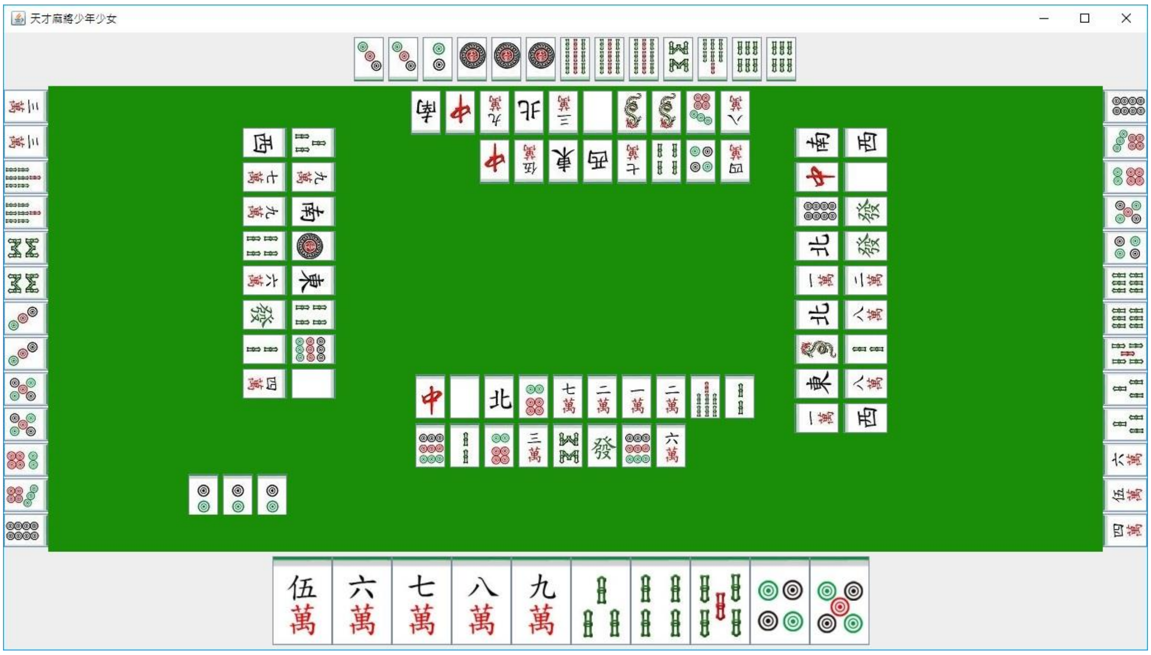


Figure 26 Draw game

4.2 The Record of the Battle between Different AI

AI_L1 will process without the locking system, AI_L2 will process with locking system and AI_L3 will process with locking system and “chow”, “pong”, “kong.”

Table 4 AI simulation 1

	AI_L1	AI_L3	AI_L1	AI_L2
Win(Include self-drawn)	9.6%	24%	9.7%	18.7%
self-drawn	2.3%	4.7%	2.3%	4.6%
Draw game	37%			

Table 5 AI simulation 2

	AI_L1	AI_L2	AI_L1	AI_L2
Win(Include self-drawn)	9.4%	18.1%	9.3%	18%
self-drawn	2.2%	4.3%	2.2%	4.3%
Draw game	45%			

Chapter 5 Conclusion

5.1 Conclusion

Mahjong is a very popular game in eastern culture. Not only the luck, but also the decision for discard will affect the result of the game. Therefore, we design a mahjong game through this project implementation. In order to let Mahjong game go on easily, designing artificial intelligence that can beat with others. To make the game more interesting, we designed the different thoughts of artificial intelligence and let these artificial intelligences to simulate the game one million times. We found the influences of different discard strategies through the simulation results, such as locking system is not always a good strategy. However, we can found that locking system is still a more effective algorithm from one million game simulation result. In addition, allowing players to manipulate and play the game easier, the research for Java user interface and characteristics of object-oriented programming are essential.

Reference

[1] The Basic and Rule of Mahjong (n.d.). Retrieved October 24,2016, from http://ezmjtw.tripod.com/

[2] Mahjong (2016, October). Retrieved October 24, 2016, from https://en.wikipedia.org/wiki/Mahjong

[3] Can AI in the field of mahjong win human beings? (2016, March). Retrieved October 26, 2016, from https://read01.com/gR354e.html

[4] What is Artificial Intelligence? (2016, November). Retrieved November 5, 2016, from http://wiki.mbalib.com/wiki/%E4%BA%BA%E5%B7%A5%E6%99%BA%E8%83%BD

[5] Artificial intelligence (2016, November). Retrieved November 16, 2016 from https://en.wikipedia.org/wiki/Artificial_intelligence

[6] Artificial Intelligence (n.d.). Retrieved November 7, 2016, from www2.scps.kh.edu.tw/teaupload/國科會計畫文獻 2.doc

[7]沈庭瑋 (2014, July). The Design and Implementation of the Mahjong Program TaKE. Retrieved November 9, 2016 from National Digital Library of Theses and Dissertations in Taiwan.

[8]陳新颺 (2013, July). The Design and Implementation of the Mahjong Program ThousandWind. Retrieved November 9, 2016 from National Digital Library of Theses and Dissertations in Taiwan.

[9] 許綸洲 (2014, June). Mahjong Artificial Intelligence Design. Retrieved November 9, 2016 from National Digital Library of Theses and Dissertations in Taiwan.

[10] The introduction of Java (2016, November). Retrieved December 5, 2016, from https://www.openfoundry.org/tw/resourcecatalog/Program-Development/Programming-Languages/java/Introduction

[11] Java Getting Started Guide - Basic Concepts for the GUI (2011, May). Retrieved October 3, 2016, from http://pydoing.blogspot.tw/2011/05/java-basic-concept-of-gui.html

[12] Java GUI (2016, April). Retrieved November 2, 2016 from http://m.blog.csdn.net/article/details?id=51120615

[13] NetBeans (2016, November). Retrieved December 5, 2016, from http://baike.baidu.com/item/netbeans/9854491?noadapt=1

[14] The introduction of Photoshop software (n.d.). Retrieved October 7, 2016, from http://www.twisu.com.tw/3/photosp/ps.htm