A Simple Implementation of a Mahjong Bot

Zhaomeng Deng

January 3, 2021

Peking University

Overview

Overview

- Mahjong is a imperfect information game with both a huge state number (about 10^{121}) and a huge average state size(about 10^{48}).

Overview

- Mahjong is a imperfect information game with both a huge state number (about 10^{121}) and a huge average state size(about 10^{48}).
- It is hard to make use of all the information.

Overview

- Mahjong is a imperfect information game with both a huge state number (about 10^{121}) and a huge average state size(about 10^{48}).
- It is hard to make use of all the information.
- Unlike other participants, My implementation of the Mahjong bot is quite simple. It is mainly based on the DFS!

Overview

- Mahjong is a imperfect information game with both a huge state number (about 10^{121}) and a huge average state size(about 10^{48}).
- It is hard to make use of all the information.
- Unlike other participants, My implementation of the Mahjong bot is quite simple. It is mainly based on the DFS!
- Of course, the bot uses some Mahjong and statatistic skills to perform will. I will make a simple introduction about it.

Concepts

The key to Chinese Standard Mahjong

- Because of some rules (8-fan to win, winner will receive points from everyone else), the speed is the most important.

The key to Chinese Standard Mahjong

- Because of some rules (8-fan to win, winner will receive points from everyone else), the speed is the most important.
- Although you reach a wait hand for a ultra-rare *Thirteen Orphans*, which is valued 88-fan, you will even lose point if other player reach a 8-fan win hand.

The key to Chinese Standard Mahjong

- Because of some rules (8-fan to win, winner will receive points from everyone else), the speed is the most important.
- Although you reach a wait hand for a ultra-rare *Thirteen Orphans*, which is valued 88-fan, you will even lose point if other player reach a 8-fan win hand.
- The basic rule of my bot is to make up a win hand as fast as possible.

The key to Chinese Standard Mahjong

- Because of some rules (8-fan to win, winner will receive points from everyone else), the speed is the most important.
- Although you reach a wait hand for a ultra-rare *Thirteen Orphans*, which is valued 88-fan, you will even lose point if other player reach a 8-fan win hand.
- The basic rule of my bot is to make up a win hand as fast as possible.
- According to the convention, we use *Shanten* and *Useful Tile* to measure the distance of a hand and the win hand.

The key to Chinese Standard Mahjong

- Because of some rules (8-fan to win, winner will receive points from everyone else), the speed is the most important.
- Although you reach a wait hand for a ultra-rare *Thirteen Orphans*, which is valued 88-fan, you will even lose point if other player reach a 8-fan win hand.
- The basic rule of my bot is to make up a win hand as fast as possible.
- According to the convention, we use *Shanten* and *Useful Tile* to measure the distance of a hand and the win hand.
- I assumed that you have a certain understanding of the rules of Mahjong.

Shanten and *Useful Tile*

Definition 1 (Shanten)

Shanten(向听) of a 13-tile hand is defined recursively:

- A 13-tile hand S is 0 Shanten if there exists a tile a, $s + a$ is a win hand.

Shanten and *Useful Tile*

Definition 1 (Shanten)

Shanten(向听) of a 13-tile hand is defined recursively:

- A 13-tile hand S is 0 Shanten if there exists a tile a, $s + a$ is a win hand.
- A 13-tile hand S is $k(k > 0)$ Shanten if there exists a tile a and another tile $b \in S$, $S + a - b$ is $k - 1$ Shanten.

Shanten shows the minimum step(draw and discard a tile) to achieve a win hand.

Shanten and *Useful Tile*

Definition 2 (Useful Tile)

A tile a is a *useful tile* of a 13-tile $k(k > 0)$ Shanten hand S if $S + a$ has a 13-tile subset T which is $k - 1$ Shanten.

- The useful tile number of a hand S is the number of tiles you can't see (in the deck or other player's hand) which is a useful tile.

Shanten and *Useful Tile*

Definition 2 (Useful Tile)

A tile a is a *useful tile* of a 13-tile $k(k > 0)$ Shanten hand S if $S + a$ has a 13-tile subset T which is $k - 1$ Shanten.

- The useful tile number of a hand S is the number of tiles you can't see (in the deck or other player's hand) which is a useful tile.
- The useful tile number shows the speed of reaching the next Shanten. The more useful tile number, the more probability you can draw a useful tile and reach the next Shanten.

Main Strategy

The Early-Game Strategy

- In the early-game (more than 3 Shanten), the hand have much uncertainty.

The Early-Game Strategy

- In the early-game (more than 3 Shanten), the hand have much uncertainty.
- My strategy is to easily minimum the Shanten and maximum the useful tile number.

The Early-Game Strategy

- In the early-game (more than 3 Shanten), the hand have much uncertainty.
- My strategy is to easily minimum the Shanten and maximum the useful tile number.
- The pesudocode of my algorithm is in the next slide:

The Early-Game Strategy

Algorithm 1 The Early-Game Strategy

$ToDiscard \Leftarrow NULL$
$MinShanten \Leftarrow +\infty$
$MaxUsefultilenum \Leftarrow 0$
for tile $x \in$ 14-tile hand S **do**
    $T \Leftarrow S - x$
    $Shanten \Leftarrow CalcShanten(T)$
    $Usefultilenum \Leftarrow CalcUsefultilenum(T)$
    if $Shanten < MinShanten$ or $Shanten < MinShanten$ and $MaxUsefultilenum = Usefultilenum$ **then**
        $ToDiscard \Leftarrow x$
        $MinShanten \Leftarrow Shanten$
        $MaxUsefultilenum \Leftarrow Usefultilenum$
    end if
end for
$Discard(ToDiscard)$

The Late-Game Strategy

- In the late-game (equal or less than 3 Shanten), you should think about more information because the 8-fan to win rule.

The Late-Game Strategy

- In the late-game (equal or less than 3 Shanten), you should think about more information because the 8-fan to win rule.
- The 8-fan hand is not easy to achieve, too.

The Late-Game Strategy

- In the late-game (equal or less than 3 Shanten), you should think about more information because the 8-fan to win rule.
- The 8-fan hand is not easy to achieve, too.
- So I use the DFS method to find the discard method which have the most probability to win in several rounds.

The Late-Game Strategy

- In the late-game (equal or less than 3 Shanten), you should think about more information because the 8-fan to win rule.
- The 8-fan hand is not easy to achieve, too.
- So I use the DFS method to find the discard method which have the most probability to win in several rounds.
- The pesudocode of my algorithm is in the next slide:

The Late-Game Strategy

Algorithm 2 The Late-Game Strategy

function CalcWinProb((13-tile-Hand S))
    return 0 When DFS depth $> MaxDFSDepth$
    $Prob \Leftarrow 0$
    for tile $t \in$ Invisible Tile Set T **do** $Prob \Leftarrow Prob + CalcWinProb14(S+t)[1]/|T|$
    end for
    return $Prob$
end function
function CalcWinProb14((14-tile-Hand S))
    if S is a win hand **then**
        return $(NULL, 1)$
    end if
    Choose a $x \in S$ that $S-x$ have max win probability $p = CalcWinProb(S-x)$
    return (x, p)
end function
$Discard(CalcWinProb14(S)[0])$

Solve Chow, Pung and Kong

- Chow, Pung and Kong is good ways to accelerate the progress of game.

Solve Chow, Pung and Kong

- Chow, Pung and Kong is good ways to accelerate the progress of game.
- But when you declare a Chow(Pung, Kong), some of your hand tile will be fixed, and you will not able to achieve some fan.

Solve Chow, Pung and Kong

- Chow, Pung and Kong is good ways to accelerate the progress of game.
- But when you declare a Chow(Pung, Kong), some of your hand tile will be fixed, and you will not able to achieve some fan.
- My strategy is also DFS. When I can declare a Chow(Pung, Kong), I use DFS (Similar to the previous part) to get the win-probability after do each choice and choose a best one.

Other Details

- The above are my core methods. There are also some important details.

Other Details

- The above are my core methods. There are also some important details.
- When your hand is a wait hand(0 Shanten), You can use other's discard tile to declare win. So I give this circumstance more weight when Searching.

Other Details

- The above are my core methods. There are also some important details.
- When your hand is a wait hand(0 Shanten), You can use other's discard tile to declare win. So I give this circumstance more weight when Searching.
- To achieve 8-fan, some hand cannot win by other's discard, and some hand cannot win by self's draw. These circumstance also need to be considered.

Other Details

- The above are my core methods. There are also some important details.
- When your hand is a wait hand(0 Shanten), You can use other's discard tile to declare win. So I give this circumstance more weight when Searching.
- To achieve 8-fan, some hand cannot win by other's discard, and some hand cannot win by self's draw. These circumstance also need to be considered.
- Other's discard tile is also not random: some tiles (Such as Winds, Dragons and 1,9)are more likely to be discarded. So I give these tiles more weight when Searching.

Performance

- The Bot's performance is quite well.

Performance

- The Bot's performance is quite well.
- It got the 6th place in The 12th Peking University Game Competition out of 190 teams, and get the 7th place in the Tournament of IJCAI 2020 Chinese Standard Mahjong AI Competition.

Thanks for your listening!