北京大学
PEKING UNIVERSITY

Sharing on Multi-player game AI Evaluation

Yushan Zhou, Wenxin Li
Peking University
25-10-2020 Beijing

Table of Contents

- A glance of Game AI Competitions
  - Motivation - Game AI evaluation is a crucial part of AI development
  - Game-based AI Competition as an AI evaluation method
  - Game-based AI competitions we collected
  - Factors that impact the evaluation in a competition
    - Competition process
    - Game properties
- Experience sharing on running multi-agent game AI competitions on our platform, Botzone
  - Fight The Landlord (FTL)
  - Chinese Standard Mahjong (Mahjong)
- Conclusions and future work

Motivation

- Game AI evaluation is a crucial part of AI development
  - Intelligence exists when we measure it!
  - The measurement depicts our imagination of intelligence!
  - The definition of AI is changing over time!
    - when AIs fulfil our expectation, we give it a new goal to pursue!
    - Checker – Chess – Go – Poker – Mahjong – …….
    - AI research is updating our recognition of Intelligence of both machine and human beings
  - Most researchers need a well defined problem
  - Holding a competition is a good way for AI evaluation , comparison and communication

Game-based AI Competition as an AI evaluation method

- Competition is an AI evaluation method
  - clear and accurate problem definition,
  - unified platform environment,
  - fair performance evaluation mechanism,
  - open datasets, and
  - baselines.
- Competition is also a research approach
  - attract more researchers to involve
  - open source after the tournaments finish
  - connect the academia and the industry (held jointly by universities and companies)
  - annual competitions help measure periodic progress
  - form a research loop (competition task– technology progress – upgraded tasks – more advanced technology

Game-based AI competitions we collected - Conferences

Abbr.	Full Name
AAAI	Association for the Advance of Artificial Intelligence
ACM-ICPC	Association for Computing Machinery - International Collegiate Programming Contest
AIIDE	Artificial Intelligence for Interactive Digital Entertainment Conference
CoG	IEEE Conference on Games
IJCAI	International Joint Conference on Artificial Intelligence
NeurIPS	Conference on Neural Information Processing Systems
NOI	National Olympiad in Informatics

The table presents the abbreviations of conferences or contests and their full names.

Game-based AI competitions we collected – Games and Organizers

Abbr.	Full Name	Games	Org.
Poker	Computer Poker Competition	Texas Hold'em	University of Alberta
SCRC	Simulated Car Racing Competition	The Open Racing Car Simulator	The University of Adelaide
StarCraft	StarCraft AI Competition	StarCraft	TU Dortmund University
FightGame	Fighting Game AI Competition	Fighting game	Ritsumeikan University
Mahjong	Mahjong AI Competition	Mahjong	Peking University
Snake	Snake AI Competition	Snake	Peking University
Pacman	Pacman AI Competition	Pacman	Peking University
Tetris	Tetris AI Competition	Tetris	Peking University
Pommerman	Pommerman Competition	Pommerman	Cinjon Resnick et al.
Hearthstone	Hearthstone AI Competition	Hearthstone	Queen Mary University of London; Otto-von-Guericke University of Magdeburg

The left two colomns of this table present the abbreviations of game AI competitions and their full names. The games used in the competitions are shown in the third colomn. The organizers or organizations are shown in the fourth colomn. specially, *GVG-AI* is similar to *GGP*, as they both use a set of games as testbed. The four-player game Pommerman adapted into the two-player game in the competition.

Game-based AI competitions we collected – Timelines of Competitions

On Botzone

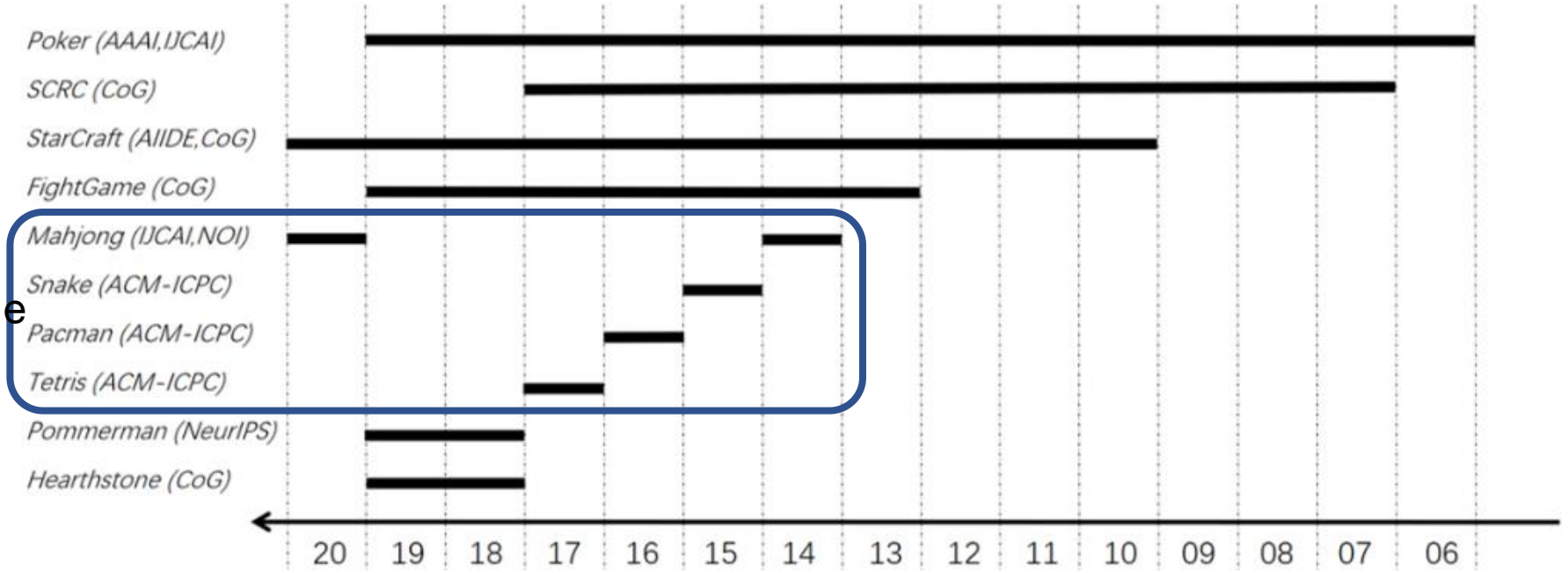


Figure 1 Timeline of Competitions. The bars mean that the competition was held in this year. The timeline is from 2005 to 2020. The content in parentheses of each competition indicates which conferences or contests the competitions have been held with. The full names of conferences can be seen in Table 2.

Game-based AI competitions we collected – Game Properties

Name	N	Rela.	Deter.	Info.	Form	S	A	Eval.
Poker	2	Competition	No	Incomp-EN	Turn	D	D	R
	3	Coopetition	No	Incomp-EN	Turn	D	D	R
SCRC	> 2	Coopetition	No	Incomp-EN-AC	Tick	C	C	C
StarCraft	2	Competition	No	Incomp-EN-AC	Tick	C	C	C
FightGame	2	Competition	No	Incomp-AC	Tick	C	D	C
Mahjong	4	Coopetition	No	Incomp-EN-AC	Turn	D	D	R
Snake	2	Competition	No	Incomp-EN-AC	Turn	D	D	R
Pacman	4	Coopetition	No	Incomp-EN-AC	Turn	D	D	R
Tetris	2	Competition	Yes	Incomp-AC	Turn	D	D	R
Pommerman	2	Competition	No	Incomp-EN-AC	Tick	C	C	C
Hearthstone	2	Competition	No	Incomp-EN-AC	Turn	D	D	C

The colomns refer to the properties of games used in competitions. (1)Name, the abbreviation of competitions' name, the same as in Figure 1, (2)N, the number of agent, (3)Rela., the relationship of the agents, including competition, cooperation, and coopetition which means that the game is both competitive and cooperative, (4)Deter., whether the game is deterministic, (5)Info., whether the game is complete information, and whether the incomplete information is caused by environment (EN) or action (AC), (6)Form, whether the game is tick-based game or turn-based game, (7)S, whether the state space of the game is continous (C) or discrete (D), (8)A, whether the action space of the game is continous (C) or discrete (D), and (9)Eval., whether the evaluation method is centralized testing (C) or real-time evaluation (R).

Factors that impact the evaluation in a competition

- Game properties
  - Number of Agents and Relationship of Agents
    - For 3 or more players , most coopetition , the sitting position, different combination of players – more complicated
  - Deterministic or Non-deterministic
    - For non-deterministic, initial states or uncertain output of actions, need more tests
  - Complete or Incomplete Information
    - Incomplete information – more sophisticated algorithm – more time to make decision
  - Turn-based or Tick-based
    - Tick-based , decision at same time , larger action space, long path to finish
  - State Space and Action Space
    - continuous space, more decision time, more complicated algorithm, more evaluation time
  - Evolution
    - A series competitions to test the evolution ability of agents

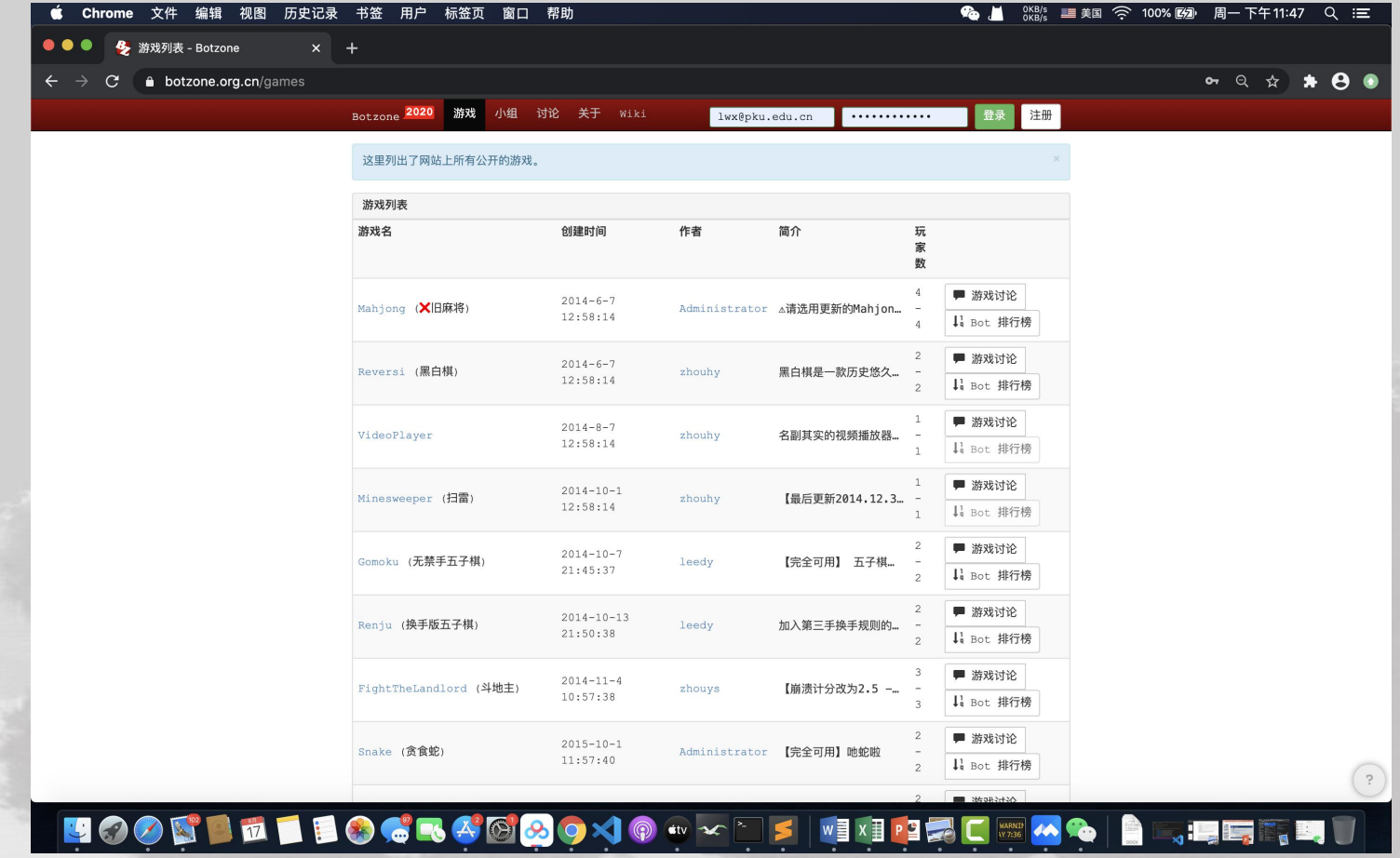
Competition process

- In a competition, game AIs compete with each other and finally a champion is selected.
- This process may be regarded as a task of sorting (giving each player a ranking) or a FindMAX(Only finding the champion).
- The basic compare operator is a match of two or more players according to the game rules.
- With the basic compare operator, the whole competition process may be regarded as a sorting task which focus on scheduling the matches of selected player pairs.
- Here we have two layers of problems to tackle – compare operator level (games used in competitions) and sorting or finding MAX level (competition process).

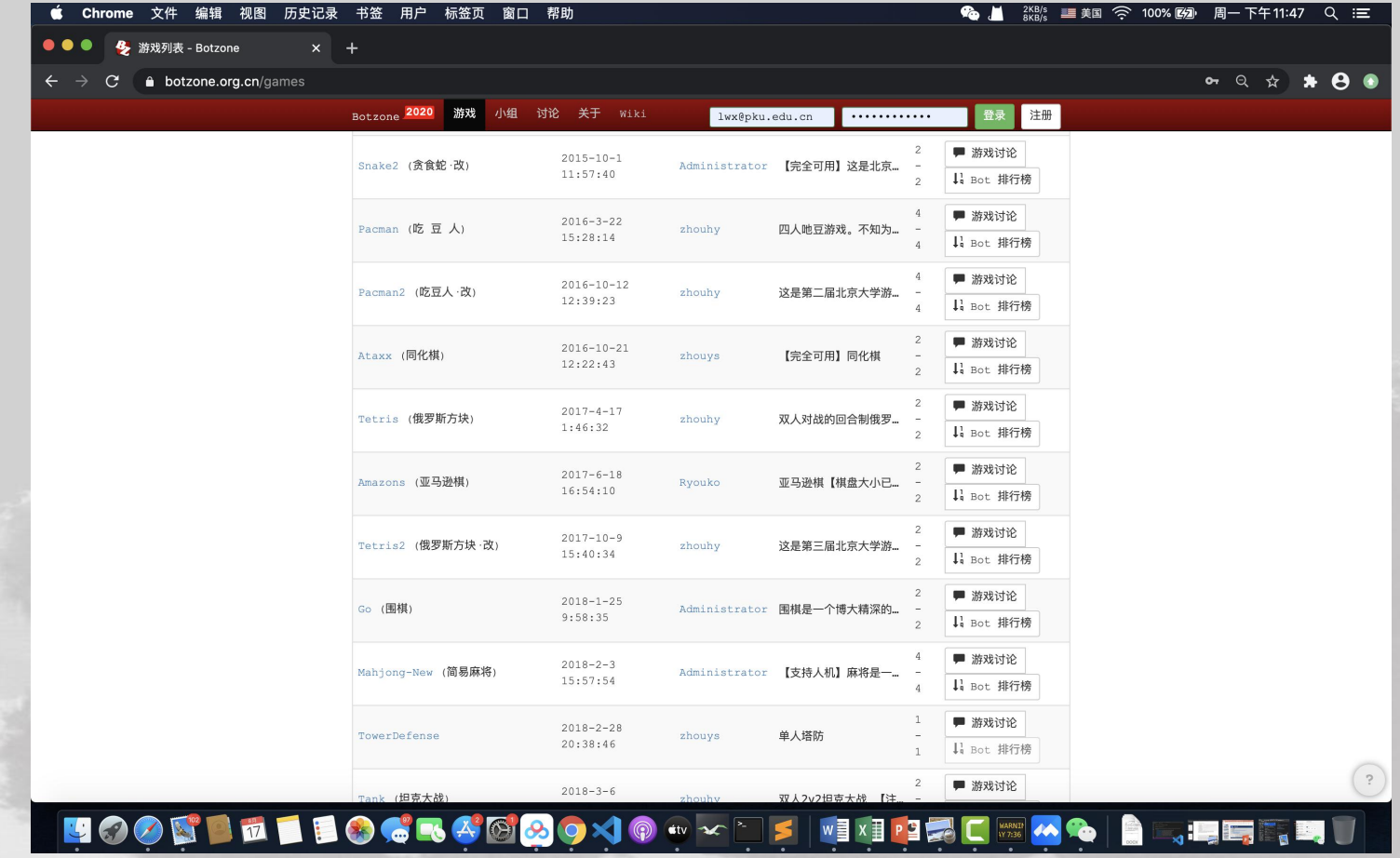
At the sorting level

- The Stage Division of Game AI Competitions
  - Basic test and advanced test. Similar to compulsory poses and free poses
  - Practice round and competitive round.
  - Qualifier and final.
- Tournament System
  - Round-robin. Run all combinations.
  - Knockout. The player or team that loses a game does not take part in later games
  - Swiss-round. Compete with a similar level player.
  - Duplicate Format. A way to eliminate the randomness in a match.
- The Method of Ranking
  - O(n * log(n)) sorting
  - Elo rating ladder ranking.
  - Number of victories achieved. Instead of scores from each match
- Competition Platform and Test Method
  - Centralized scheduling evaluation.
  - Platform combining real-time evaluation, dynamic ranking, and unified evaluation. Botzone

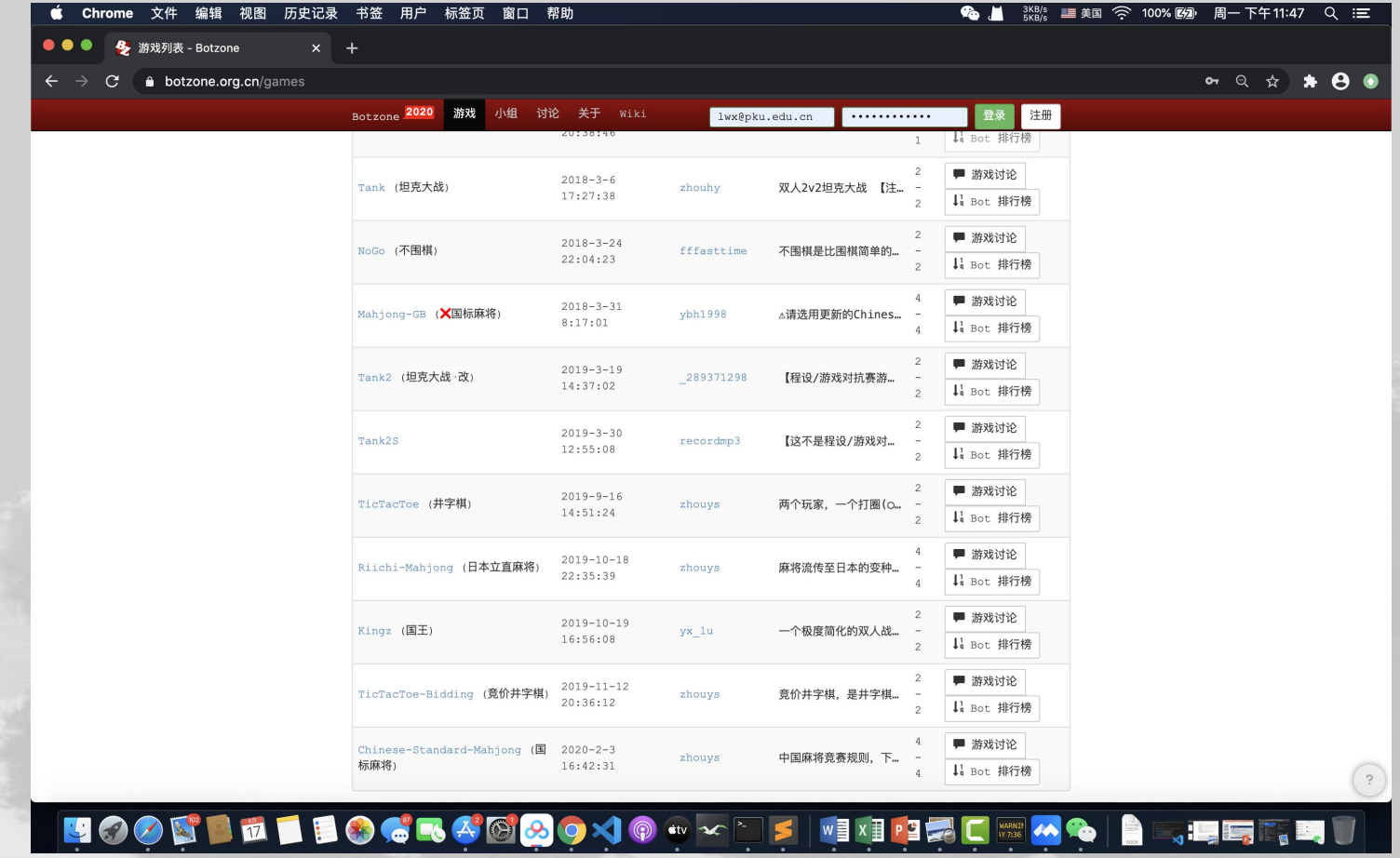
Online Platforms for a long term Competition(http://www.botzone.org.cn as an example) - games



Online Platforms for a long term Competition - games

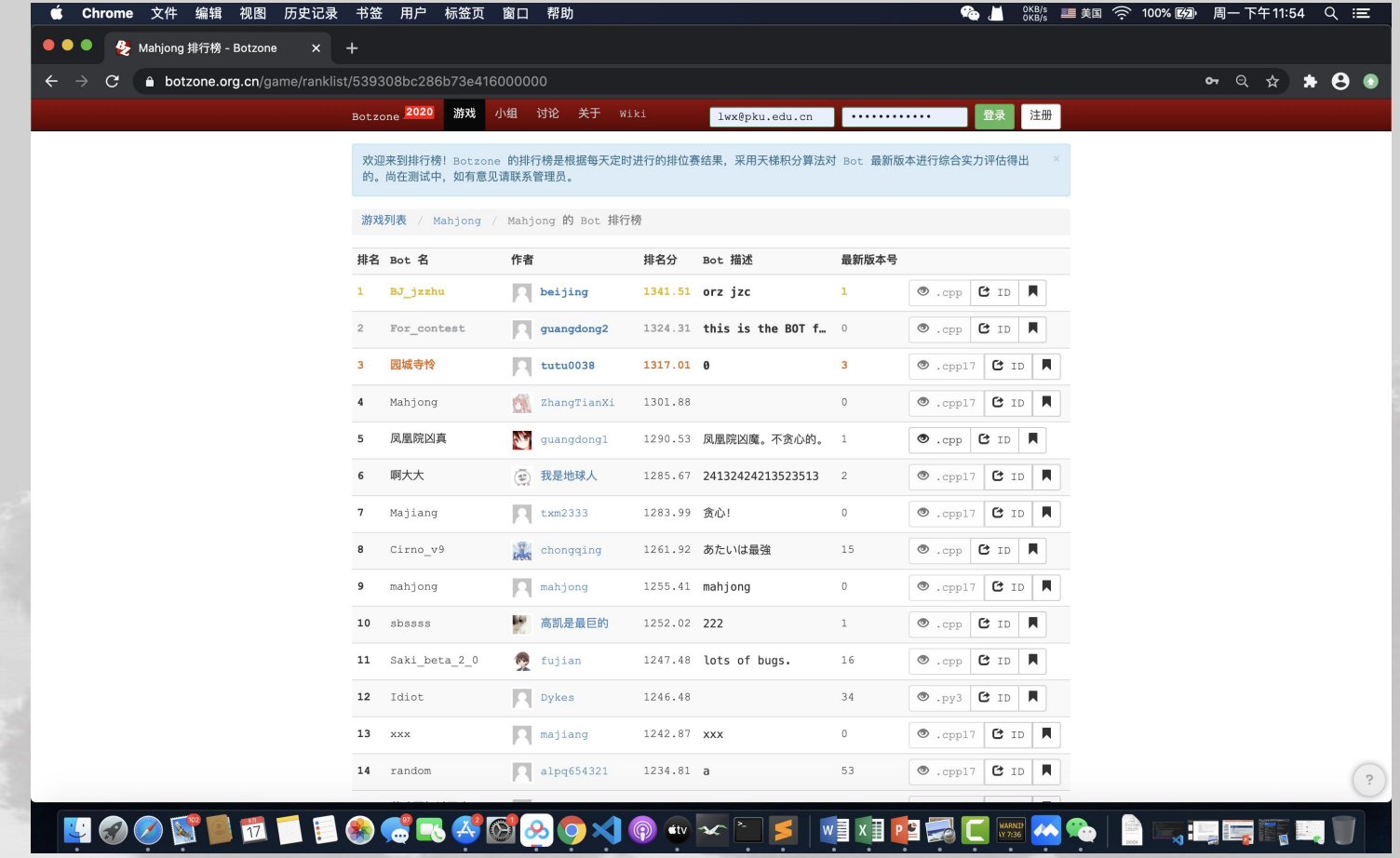


Online Platforms for a long term Competition - games

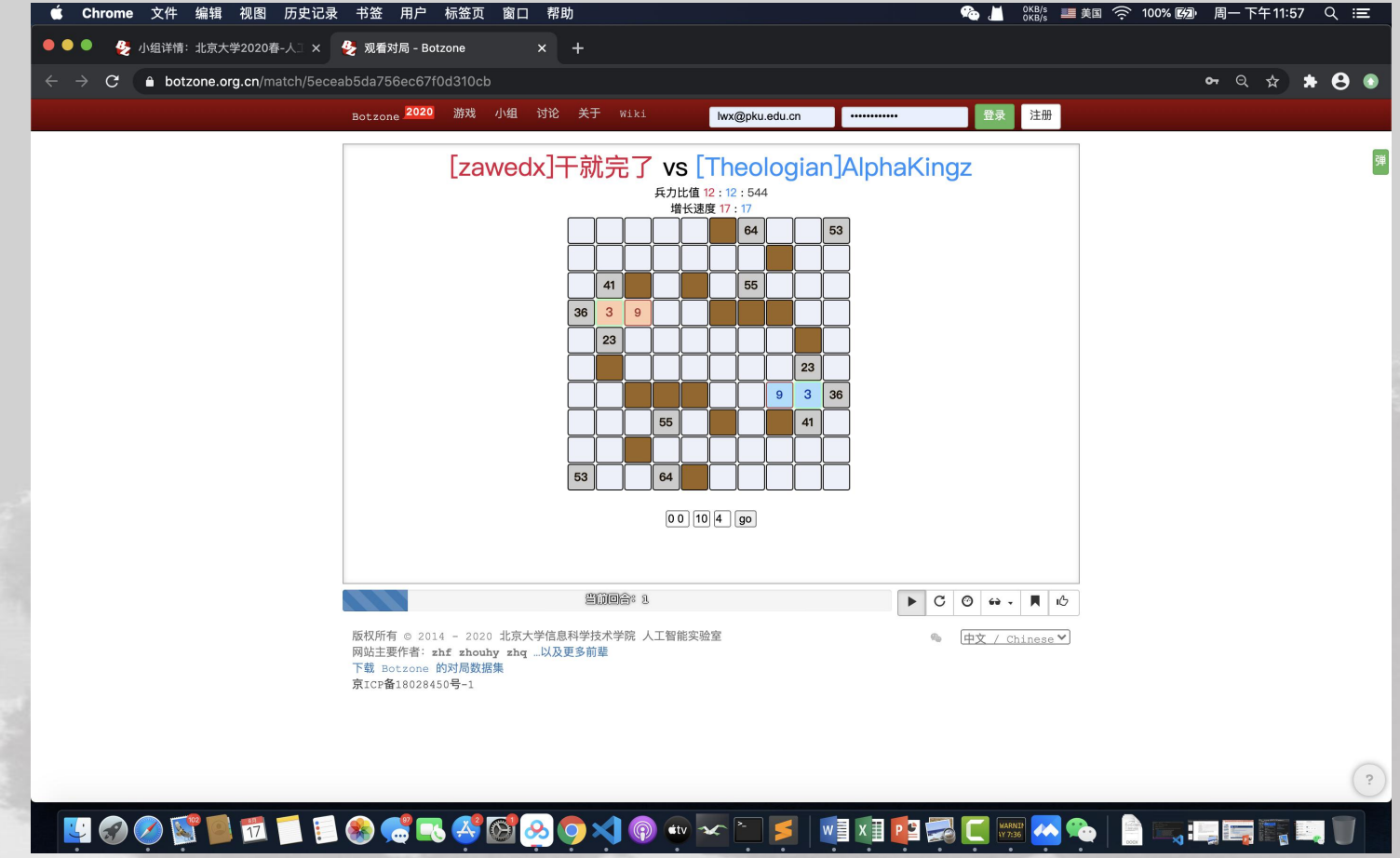


Online Platforms for a long term Competition - competitions

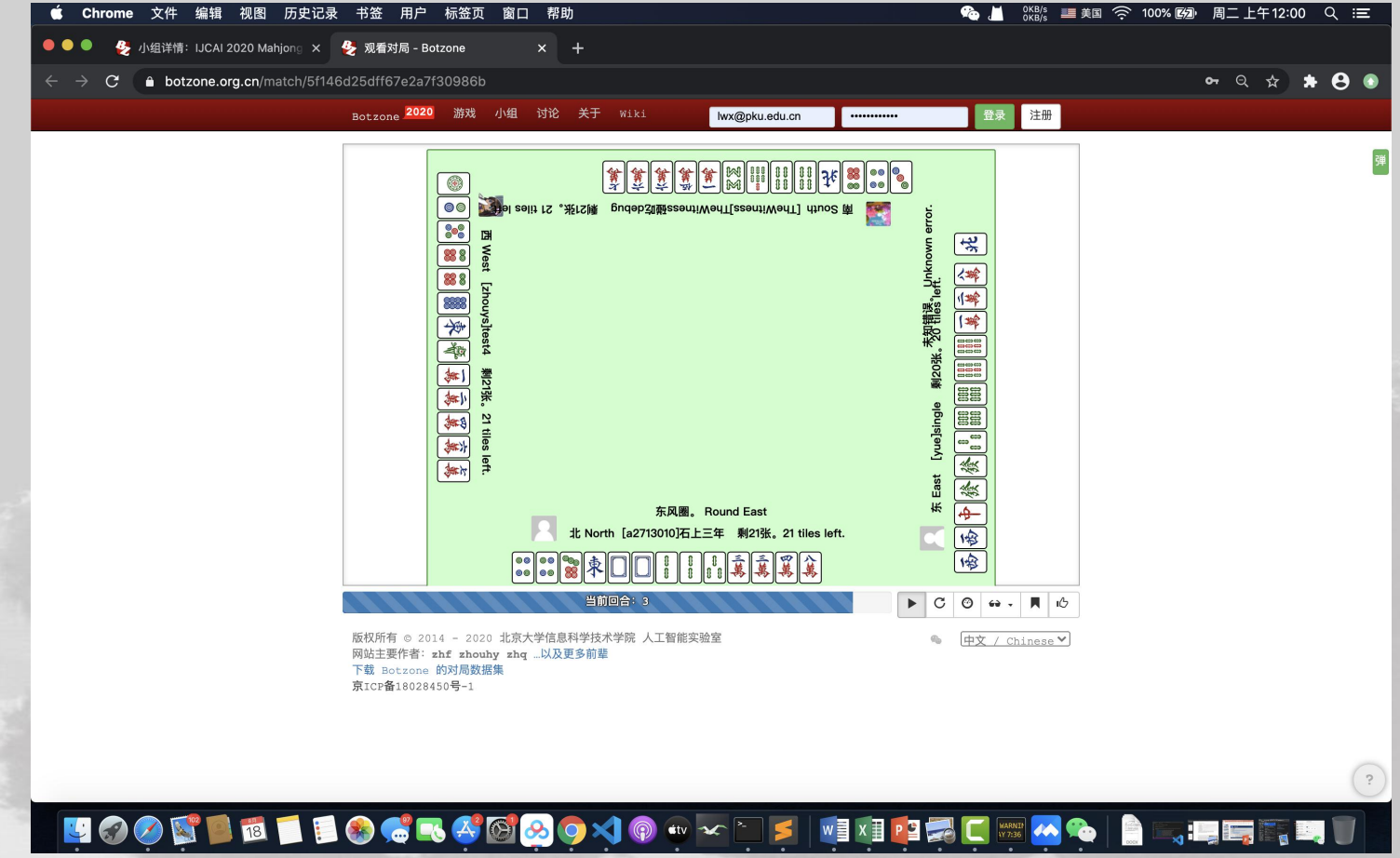
Online Platforms for a long term Competition – ranking list of AI



Online Platforms for a long term Competition – replay of a match

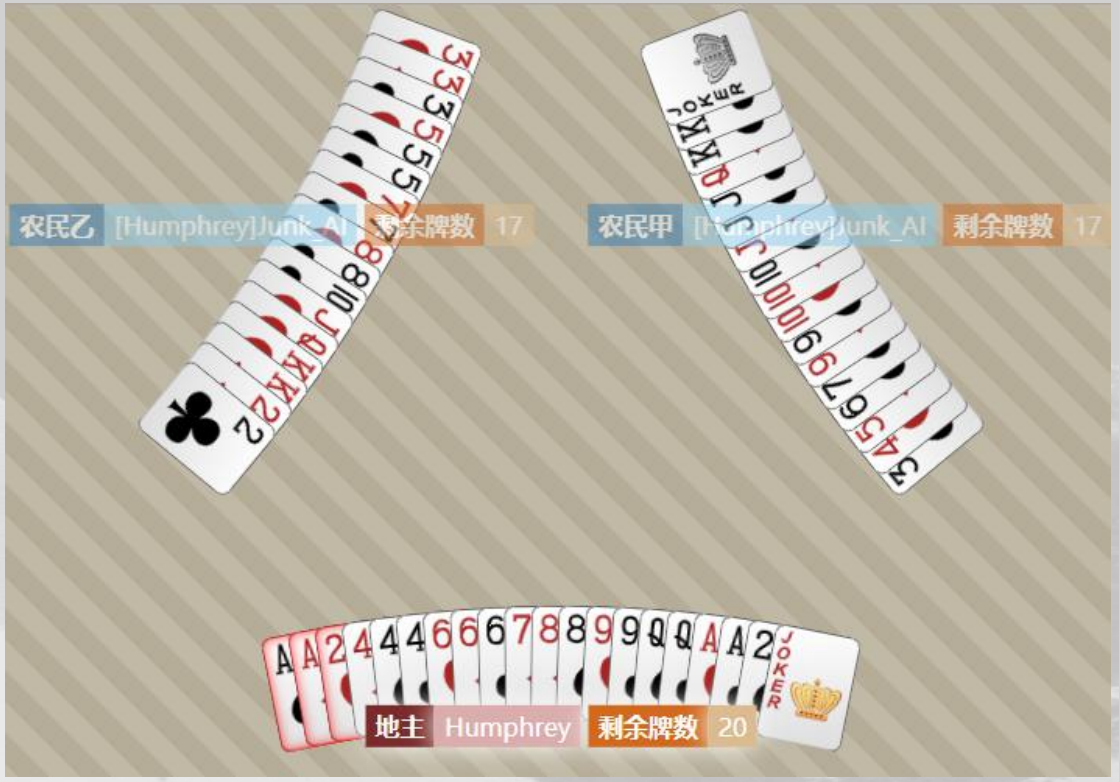


Online Platforms for a long term Competition – replay of a match

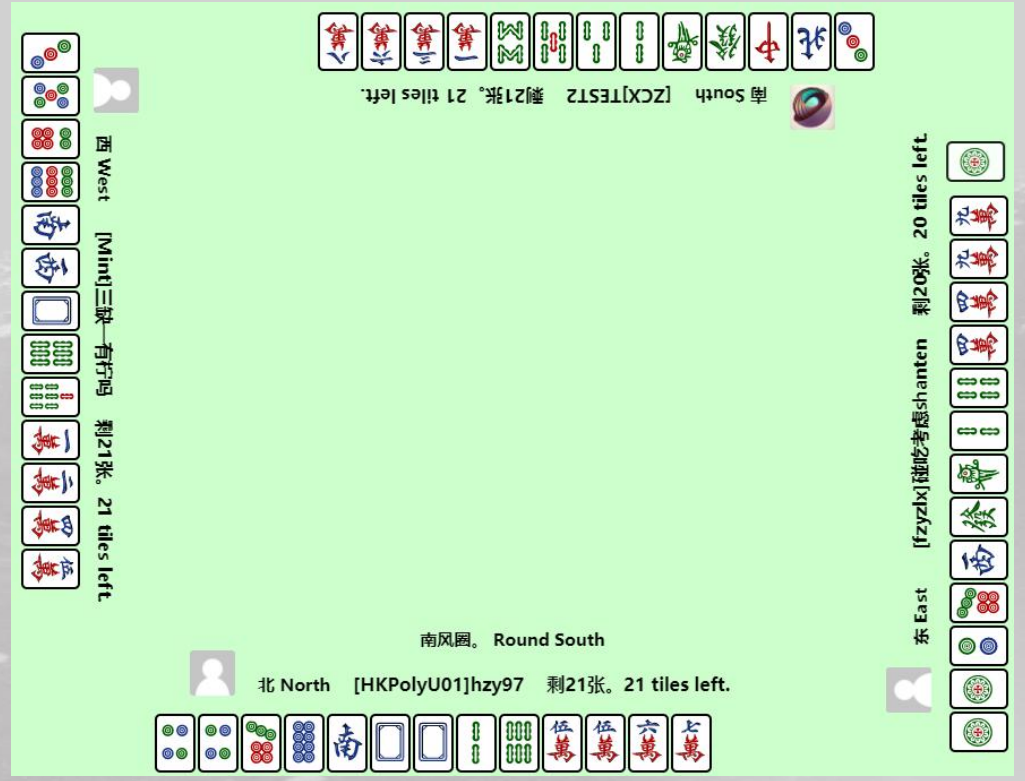


Experience sharing on multi-agent game AI competitions

FightTheLandlord



Mahjong



FightTheLandlord (FTL)

- Classic FTL includes confrontation between landlord and farmers, and cooperation between farmers.
- We adapt the game from classic FTL, and it differs from the two aspects: No bidding, and no multiplier.

FightTheLandlord (FTL)

- Classic FTL includes confrontation between landlord and farmers, and cooperation between farmers.
  - It is difficult to distinguish two farmer AI algorithms for they gained the same scores.
  - It is more difficult to measure the cooperative ability of two AI algorithms who can't communicate with each other.
  - We reduced the game from three-player game to two-player game, where the two farmer use the same AI algorithm, but they couldn't communicate with each other.

FightTheLandlord (FTL)

- We adapt the game from classic FTL, and it differs from the two aspects: No bidding, and no multiplier.
- The landlord is assigned at the beginning, and we focus on players' ability of dealing with hand.
- However, The landlord and the farmer are not homogeneous.
  - The landlord receives 20 cards while the farmer receives 17 cards at the beginning.
- Two sides switch roles but keep cards by position, and sum the scores in the pair of matches.

FightTheLandlord (FTL)

- However, considering that the game is greatly affected by the initial hand,
- When one hand is outstanding, there is a higher probability for a draw to occur when hands are swapped.
- We sum two parts up to obtain the score, (i) win or lose as large points, (ii) behavioral based small points, playing specific category of hands like Rocket, Bomb, Airplane, etc.

FightTheLandlord (FTL)

- Three-player game -> two-player game
  - Two farmers use the same AI algorithm, but no communication is allowed.
- Two sides switch roles but keep cards by position, and sum the scores in the pair of matches
  - We expect AI to make decisions in different side of the same situation.
- To Eliminate ties, the score is composed of two parts
  - Win or lose as large points
  - Behavioral based small points, playing a specific combination of cards.
- In a Swiss/knockout contest, if any match is a draw, the match will be restarted.

Chinese Standard Mahjong

- Mahjong is a 4-player game. Similarly, Mahjong also generates the Wall by assigning random seeds.
- In Chinese Standard Mahjong, four players draw from the same Wall.

Chinese Standard Mahjong

- To eliminate the influence of position, we run the full arrangement of positions for the 4 matched players, which means the 4 players will play 24 times with the same Wall.
- But as we know, claiming any card will influence the next drawn tile from the Wall, thereby introducing new uncertainty, and make it difficult for us to measure the strength of AI algorithms.
- Therefore, we adopted the Duplicated Format from international competitions, dividing the Wall into four sets for each position, and making sure each players draw from its own Wall in its position.
- Meanwhile, the eight flower tiles are removed.

Mahjong

- Assumption
  - We expected N teams will participate in the contest.
  - Duration of a match is D minutes.
  - P matches in parallel.
  - There are total M matches in the contest.
  - For each set of players matched together, we schedule Q matches in Duplicate Format.
- The time cost is $T = \frac{MQ}{1440P}$ days.

Mahjong

- Assumption
  - We expected $N \approx 100$ teams will participate in the contest
  - Duration of a match is $D \approx 5$ minutes.
  - $P = 32$ matches in parallel.
  - There are total M matches in the contest. ($M = f(N)$)
  - For each set of players matched together, we schedule Q matches in Duplicate Format.
- The time cost is $T = \frac{MD}{1440P} = f(N)Q * \frac{5}{1440*32} = \frac{f(N)Q}{9216}$ days.

- As for the contest system in this Mahjong AI competition, there are several choices.
  - Round-robin competition
  - Knockout contest
  - Swiss round.

Round-robin competition

- Advantages
  - In theory, a round-robin tournament is the fairest way.
- Disadvantages
  - The duration of contest is too long. (Just like bubble sort in sorting algorithms!)
    - We expected $N \approx 100$ teams will participate in the contest
    - Duration of a match is $D \approx 5$ minutes.
    - $P = 32$ matches in parallel.
    - $Q = 24$ in Duplicate Format.
    - There are total M matches in the contest. ($M = f(N) = C_N^4 = C_{100}^4 = 3921225$)
    - The time cost is $T = \frac{MQD}{1440P} = \frac{94109400}{9216} \approx 10211 (days)$
  - If we want to finish the contest in 14 days
    - We would need $P = \frac{MQD}{1440T} = \frac{3921225 \times 24 \times 5}{1440 \times 14} \approx 23340$ machines.
  - We may reduce the time consumed for each match D, but it's beyond the scope of this talk.

Round-robin competition

- Therefore, when the number of players is large, we won't run a round robin contest.
- When the number of players is small, the round robin tournament is ideal to produce a fair ranking.

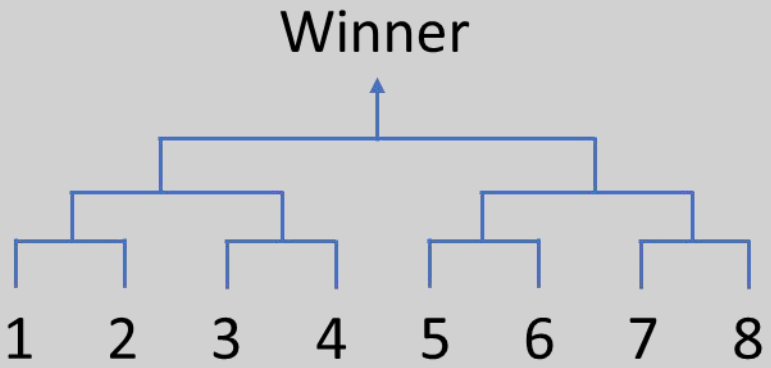
Knockout contest (Single Knockout)

- We have used ELO ranking followed with knockout contest previously.
- The initial matches are derived from the ELO ranking in Snake format.

A	B	C	D	E	F	G	H
01	02	03	04	05	06	07	08
16	15	14	13	12	11	10	09
17	18	19	20	21	22	23	24
32	31	30	29	28	27	26	25

Fig: Group in snake format

Knockout contest (Single Knockout)

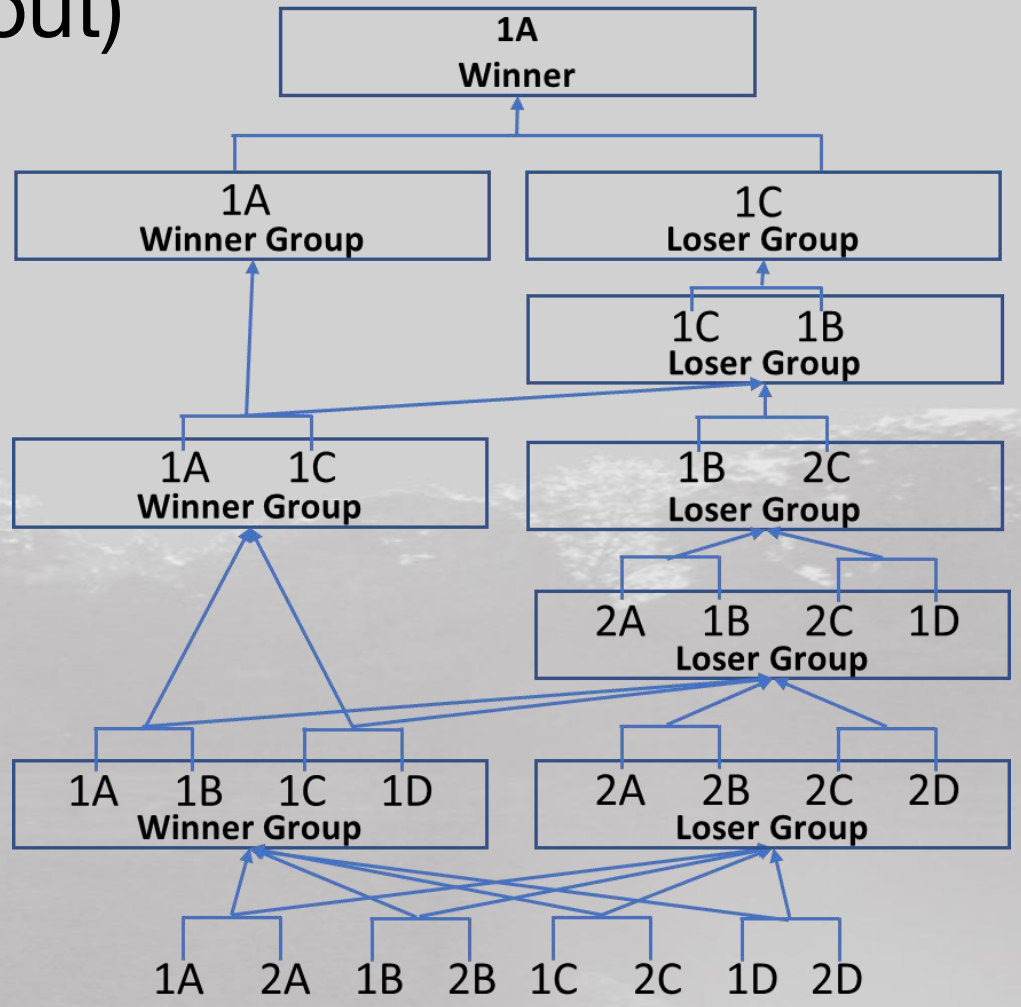


- Here we define the complexity of a contest is the possible number of matches, expressed in Big O notation.
- The complexity of knockout is $O(N)$.
- Generally $\frac{N}{2}$ matches. N is the number of teams.
- However, player will be knocked out upon one single lose. A single bad or unlucky match can nullify many preceding excellent ones.

Knockout contest (Double Knockout)

- In double knockout, every lost player will have a chance of resurrection, with a complexity of $O(N)$ too.

- Note
  - Winner Group: Never lose
  - Loser Group: Lose once



Swiss round

- This contest system is suitable for a large number of players. The complexity is $O(\frac{N*lgN}{H})$, H is the number of players in a match. N is the number of teams.
- The $T = \frac{MD}{1440P} = \frac{100 \times cel(\log 100)}{4} \times \frac{24 \times 5}{1440 \times 32} \approx 0.458\ (days)$
- Assuming that $Q = 24k,\ k \in Z^+$, if the competition should be finished in 14 days, we have $\max Q = \frac{1440PT}{MD} = \frac{1440 \times 32 \times 14}{100 \times \frac{cel(\log 100)}{4} \times 5} \approx 737,\ s.t.,\max Q = 720,\ T = 13.7\ (days)$

Swiss round

- Compared to the knockout, everyone will not be knocked out till the end, and the total number of matches won't be too large.
- But sometimes the first and third players won’t be matched throughout the contest according to swiss system.

Contest Rule

- Pseudo Code of Contest Rule

```
// Swiss round && Duplicate Format
N := Player count
P[] := Players
TotalScores[] := Zeros
Rounds := log2 length(P[])
Fill P[] to a multiple of 4 with Sample Bots
Repeat Rounds times
    For each consecutive 4 players as Quad in sorted P[]
        Repeat 4 times as Wind
            Seed := random integer
            QuadScores := Zeros
            For each A(4,4) premutation Prem of Quad
                Scores = Run a match between Prem with Seed and Wind and get scores
                For each Player in Prem
                    QuadScores[Player] += Scores[Player]
            For each Player in Quad
                TotalScores[Player] += QuadScores[Player] / (Rounds×10000) + 5 − rank of Player in Quad by QuadScores
    Sort P by TotalScores
```

Mahjong AI Competition

- Finally, we adopted the Swiss system with Duplicate Format in Student Mahjong AI Competition, taking time into consideration.
  - There are still some problems, for swiss system fails to give a detailed ranking list, for we score each participant according to his rank.
  - Evaluation is still an open problem when the circle of strategies exists.
- In IJCAI 2020 Mahjong AI Competition, we will adopt this contest system as well.
  - Evaluation in IJCAI 2020 Mahjong AI competition is easier, for the detailed ranking list is not necessary.

Conclusions and future work

- Statistical fairness and unavoidable randomness
- Quantitative analysis of randomness
  - Measure how much the randomness is reduced by the contest system.
- Choosing reasonable contest system according to the schedule.
  - Time cost of a contest: (i) Duration of a match, (ii) Number of teams, (iii) Degree of parallelism when running matches
- If we want to determine the top N of all teams
  - Ordered top N: Round-robin
  - Unordered top N: Knockout / Swiss-round

Thank You !