

## Game Rules

Chopsticks is a hand game for two players, in which players extend a number of fingers from each hand and transfer those scores by taking turns to tap one hand against another. Chopsticks is an example of a combinatorial game, and is solved in the sense that with perfect play an optimal strategy from any point is known.

- Each player uses both hands to play the game, the number of fingers extended on a hand shows the number of points that the hand has.
- Both players start with each hand having one point one finger extended on each hand.
- The goal of the game is for a player to force their opponent to extend all of their fingers and thumbs on both hands or to force the player to extend all their fingers and thumb and one hand if their other hand is already out.
- A hand with all fingers and its thumb extended is called a dead hand and is taken out of play.
- Players take turns to tap their live hand(s) against another live hand
- The number of points on the tapping hand is added to the number on the tapped hand, and the player with the tapped hand extends their digits to show the new score. The tapping hand remains unchanged.
- A player may tap their two hands together to transfer points from one hand to the other. This is called a split. For example, if a player has 4 on one hand and 2 on the other, they could split to have 3 on each hand.

## Variations

- Chinese/American Rules: The Chinese Chopsticks game is the Misere version of Chopsticks. In Chinese version, the goal of the game is for a player to extend all of his fingers and thumbs on both hands. What's more, the number of points on the tapped hand is added to the number on the tapping hand. The Chinese rules are just opposite to American rules.
- Fingers' number on hand: In Chinese Chopsticks game, the total number that one hand can represent is ten, instead of five in America. In my opinion, the total finger number on one hand can change into any positive integer.
- Pass rule: In some variations, player is permitted to exchange his two hand's number. For example, change  $[3,1]$  into  $[1,3]$ , which can effectively be used to pass the turn.

## Division of Labour

- Shao Junning for game part and solver part
- Hua Ruiyang for GUI part.

## Upper Bound Calculation

Four hands mean four independent variables, So the game's complexity is  $O(n^4)$ ,  $n$  is finger number. In most cases,  $n$  is equal or less than ten, so the number of positions is less than 10000. If we regard symmetric positions as the same position, the number of positions is less than 3000, which is quite small scale for computer.

## Solver & GUI

We use python to make a solver for loopy game and GUI. Chopsticks game has 4 variables which represent four hands, so we use a tuple like (hand1, hand2, hand3, hand4) to represent the position. The solver is a loopy solver that professor taught in class.

we use Tkinter to implement the GUI. To be specific

## Analysis & Testing

In different variations, testing result is different. Overall, when hand's total number  $n$  increases, Chopsticks becomes a draw game. Here is a table that shows the tendency of this game. The example's configuration is "American Rule, No split, No pass".

n	win position	lose position	draw position	total position	result
2	2	2	0	4	lose,3
3	16	10	0	26	lose,7
4	30	21	29	80	draw
5	62	48	90	200	draw
6	53	32	295	380	draw
7	177	144	419	740	draw
8	216	186	758	1160	draw
9	171	96	1667	1934	draw
10	146	72	2526	2744	draw

## How To Install/Play

You can run the Interface.py to start playing the game. Click the option and you will see the introduction on the right. Click the START button to play, and UNDO to cancel, and REDO to return. You can click SHOW VALUE button at any time to see the prediction.