The Computer Game Model of Contract Bridge

MEI Xian[1], ZHANG Dianlong[1], LIAO Qijun[1], JIANG Yanxin[2], LI Zhiguang[1]

1. Harbin University of Science and Technology, Harbin 150080
E-mail: meixian@hrbust.edu.cn

2. Heilongjiang University, Harbin 150080
E-mail: jyx1977@sohu.com

Abstract: Computer game is an important field of artificial intelligence. Contract bridge is a kind of athletics project backlash using cards. It is an incomplete information game. We analyzed the contract bridge game process and described a computer game model in this paper in the following six respects, ranging from the participant, historical collection, participant function, information space, natural probability distribution function and the participant preferences six respects. This model will be used for studying the contract bridge computer game theory or program algorithm.

Key Words: Contract Bridge, Computer Game, Game Model

1 Introduction

Computer game is one of the most challenging topics in the field of AI [1] , which brings many important theories and methods for AI. It is usually divided into two types: complete information and incomplete information [2]. Most of chess games are complete information. Chess, Chinese chess and Gobang computer game studies have made many achievements [3]. The most of card games are incomplete information [4]. Studies of card games lag behind the chess's [5]. Contract bridge is a trick-taking game using a standard deck of 52 playing cards. It is played by four players in two competing partnerships, with partners sitting opposite each other around a table. It has become the performances of Winter Olympics in 2012 and the regulation game of National University Games in 2007. At present, most research of contract bridge game is oriented to design and optimize bid algorithm or play cards algorithm [6]. The contract bridge computer game model theory research is still at the exploratory stage. This paper described a contract bridge computer game model from the participant, historical collection, participant function, information space, natural probability distribution function and the participant preferences six respects.

2 The Computer Game Model of Contract Bridge

To describe an incomplete information dynamic game system model, we need to expatiate the participants, the process history, the participants function, the information space, the natural probability distribution function and the participants revenue function [7]. The following describes the Computer model of contract bridge during a round.

$$\Gamma = \{N, H, P, I, p, u\} \qquad (1)$$

N is the participants' collection. H is the aggregate of the whole process history. P is the participants function. I is the information space. p is the natural probability distribution function. u is participants preferred which is the revenue function.

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2.1 Participants' collection

There are four players in two fixed partnerships. Partners sit face to face with each other. It is traditional to refer to the players according to their position at the table as North, East, South and West. North and South are partners playing against East and West.

Each participant is described as n_i. All participants are described as N.

$$N = \{-1, 0, 1, 2, 3\} \qquad (2)$$

Each player has a number as starting from the dealer, such as 0,1,2,3. Assigning a number -1 to means shuffle natural random process. The main function of random process is shuffle cards order and giving 13 initial cards for each player.

2.2 History

A round of game process is dealing, competitive auction, and playing cards to battle it out.

Shuffle and Deal (D): Code the card by suits and points in natural order, range from 0 to 51; shuffling process can be realized by exchanging the current cards position into any card several times. the i^{th} shuffle , swap (p_i, p_j), which i = 0,1,2 ... ..., 51; j = Rand mod 52, Rand is a random positive integer, p_i is the i^{th} card position . Then deal card to four players is in circle. beginning from the number 1 participant , then the number 2,the number 3,the number 0, when 52 cards have been deals out clockwise in cycle, each player having 13 cards.

Auction : According to the Bridge auction laws, the dealer first bids, then left player bids, and does clockwise rotation. When a player bids a contract and the other players don't call, that is a contract, the auction ending [8].

Contract is composed of actual bid, double, and redouble. Actual bid is made up of odd trick and denomination. Odd trick is a natural number ranging from 1 to 7. Denominations have clubs, diamonds, hearts, spades and no trump [9]. Encoding the actual bid in ascending order ranges from 1 to

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35. Also coding 36 for double bid, 37 for redouble bid, 38 for the end of the bid, 0 for a pass, d is the number of current consecutive pass, $d \in [0,3]$. If anyone bids, then the auction continues until there are three passes in succession, and then stops. After three consecutive passes, the last bid becomes the contract. The team who made the final bid will now try to make the contract. The first player of this team who mentioned the denomination (suit or no trumps) of the contract becomes the declarer. The declarer's partner is known as the dummy. Let c_i is the bidding system of the i^{th} bid A_i. Bid_i is actual bid retention during i^{th} race, so that is the code of the first player auction , that is When you make the i^{th} auction, the price and specified suit should be higher than the previously bidding. Double bid can only be used after the actual bid and redouble can only be used after double. When a bidding system was give up after three consecutive called, then the bid ended.

$$Pass = \{0 \mid d < 2\} \quad (3)$$

$$Bid_i = \{\forall c \mid Bid_{i-1} < c \le 35\} \quad (4)$$

$$Db = \{36 \mid 1 \le c_{i-3} \le 35 \wedge c_{i-2} = 0 \wedge c_{i-1} = 0 \vee 1 \le c_{i-1} \le 35\} \quad (5)$$

$$RD = \{37 \mid c_{i-3} = 36 \wedge c_{i-2} = 0 \wedge c_{i-1} = 0 \vee c_{i-1} = 36\} \quad (6)$$

$$Finish = \{38 \mid d = 2 \vee i > 3\} \quad (7)$$

$$c_i \in Pass \bigcup Bid_i \bigcup Db \bigcup RD \bigcup Finish \quad (8)$$

Playing cards: The player to the left of the declarer leads to the first trick and may play any card. Immediately after this opening lead, the dummy's cards are exposed. The dummy should arrange them neatly in suits play as instructed by declarer.

The defender at the declarer left side plays the first attack called lead. Then dummy put his cards face up on the table, the declarer plays his card instead of him.

The first round cards process history may as follows:

H_{11}, is the opening lead, which is the first card played in the first round;

S, is the dummy's cards are exposed in the first round;

H_{12}, the second card played in the first round.

H_{13}, the third card played in the first ground;

H_{14}, the forth card played in the first ground;

G_1, is the winner fold cards back of the first round;

Therefore, the subset process history aggregate of the first round

$R_1 = \{H_{11}SH_{12}H_{13}H_{14}G_1\}$

The i^{th} round of the jth play can be expressed as H_{ij};

The i^{th} round of the fold can be expressed as G_i;

The subset process history aggregate of the i^{th} round is expressed as

$$R_i = \{H_{i1}H_{i2}H_{i3}H_{i4}G_i\} \quad (9)$$

So total process history aggregate is

$$H = \{D\ Auction R_1R_2R_3...R_{13}\} \quad (10)$$

2.3 Participant function

Participant function is that P (h) maps each subset process history h into a natural or other participant. Game begins with the natural shuffling and dealing, that is P (ф) = -1. And then auction by participants 1, that is, P (D) = 1. Participants complete the race called the A1 0 a clockwise direction after the participant in a competition called the turn, that $P(DA_1)=1$. Then turning to the next participant in clockwise order, the i^{th} competition called then the (i mod 4)th participant called, that

$$P\ (DA_1 .\ .. A_i) = i \bmod 4 \quad (11)$$

All competitive auctions are completed, The player to the left of the declarer leads to the first trick, that is

P（D Auction）=P（DA_1... Contract=(Declarer+3) mod 4 (12)

After this opening lead, the dummy's cards are exposed and play as instructed by dealer.

$P(DAuctionH_{11})=P(DAuctionH_{11}S)=(Declarer+2)mod4$ (13)

After the dummy's cards are exposed and the player to the right of the declarer plays, that is

$$P(DAuctionH_{11}\ SH_{12}) = (Declarer+1) \bmod 4 \quad (14)$$

That whose denomination is the biggest wins 1 stick during a round and guides next round play, that is

$$P(DAuctionH_{11}\ SH_{12}\ H_{13}\ H_{14}) = W_1 \quad (15)$$

$$P(DAuctionR_1)=P(DAuctionH_{11}SH_{12}H_{13}H_{14}A_1)= W_1 \quad (16)$$

The ith round Participant function is $i \in [1,13]$

$$P(DAutionR_1R_2R_3...R_{i-1}) = W_{i-1} \quad (17)$$

$$P(DAutionR_1R_2R_3...R_{i-1}H_{i1}) = (W_{i-1}+1) \bmod 4 \quad (18)$$

$$P(DAutionR_1R_2R_3...R_{i-1}H_{i1}\ H_{i2}) = (W_{i-1}+2) \bmod 4 \quad (19)$$

$$P(DAutionR_1R_2R_3...R_{i-1}H_{i1}\ H_{i2}\ H_{i3}) = (W_{i-1}+3) \bmod 4 \quad (20)$$

$$P(DAutionR_1R_2R_3...R_i) = W_i \quad (21)$$

2.4 Information

The participant who takes the first attack has a different information space after the dummy's cards are exposed. Before that, The information space of first attacker only has bid record and the cards in his hands. But after that, each participant's information space makes up of bidding record, the cards in their hands, the process history and the dummy cards. Let I_{ij} means the participant i information space in the j round, the participant initial information space of first play in the first ground is

$$I_{11} = Aution \bigcup P_{11} \quad (22)$$

Auction is bidding process information set, P_{11} for the first one in the first one participant in the hands of the cards. After the first attacks dummy light card, then the i^{th} round of the j^{th} participant in the information set is I_{ij}:

$$I_{ij} = Aution \bigcup P_{iDummy} \bigcup P_{ij} \bigcup T_{ij} \quad (23)$$

$$T_{ij} = R_1R_2...R_{i-1}H_{i1}H_{i2}...H_{ij-1} \quad (24)$$

P_{iDummy} is the hold card by dummy , T_{ij} is the i^{th} round the j^{th} deal card.

2.5 Random Shuffling

During a round of bridge game, the natural behavior only happened in the initial shuffle and deal stages. In the subsequent processes of bid and play cards natural has no impact. Exchanging in accordance with this random shuffling algorithm, each deputy of the hand function of the probability of the initial license is:

$$\rho(Ci) = \frac{1}{C_{52}^{13} C_{39}^{13} C_{26}^{13}} \quad (25)$$

2.6 Participant Preferences

Participant preferences are revenue function which defined during whole process history. Participants complete the contact

$$OddTrick \le 7 - \sum_{i=1}^{13} | W_i - n_{Declarer} | \bmod 2 \quad (26)$$

When participants complete contact, they get basically points and bonus points.

The participants don't complete contact, that is

$$OddTrick > 7 - \sum_{i=1}^{13} | W_i - n_{Declarer} | \bmod 2 \quad (27)$$

When participants don't complete contact, the defenders get correspondence penalty points.

3 Conclusion

In this paper, we have done some research on design of Computer game model of contract bridge, describing from the participant aggregate, the process history aggregate, the participant function, the information space, natural probability distribution function and the participants revenue function. It provides a theoretical basis for the contract bridge Computer game and also designs the corresponding algorithm for shuffling and dealing.

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